Swimming Pool Pest Management: A Training Manual for Commercial Pesticide Applicators and Swimming Pool Operators: Category 5A
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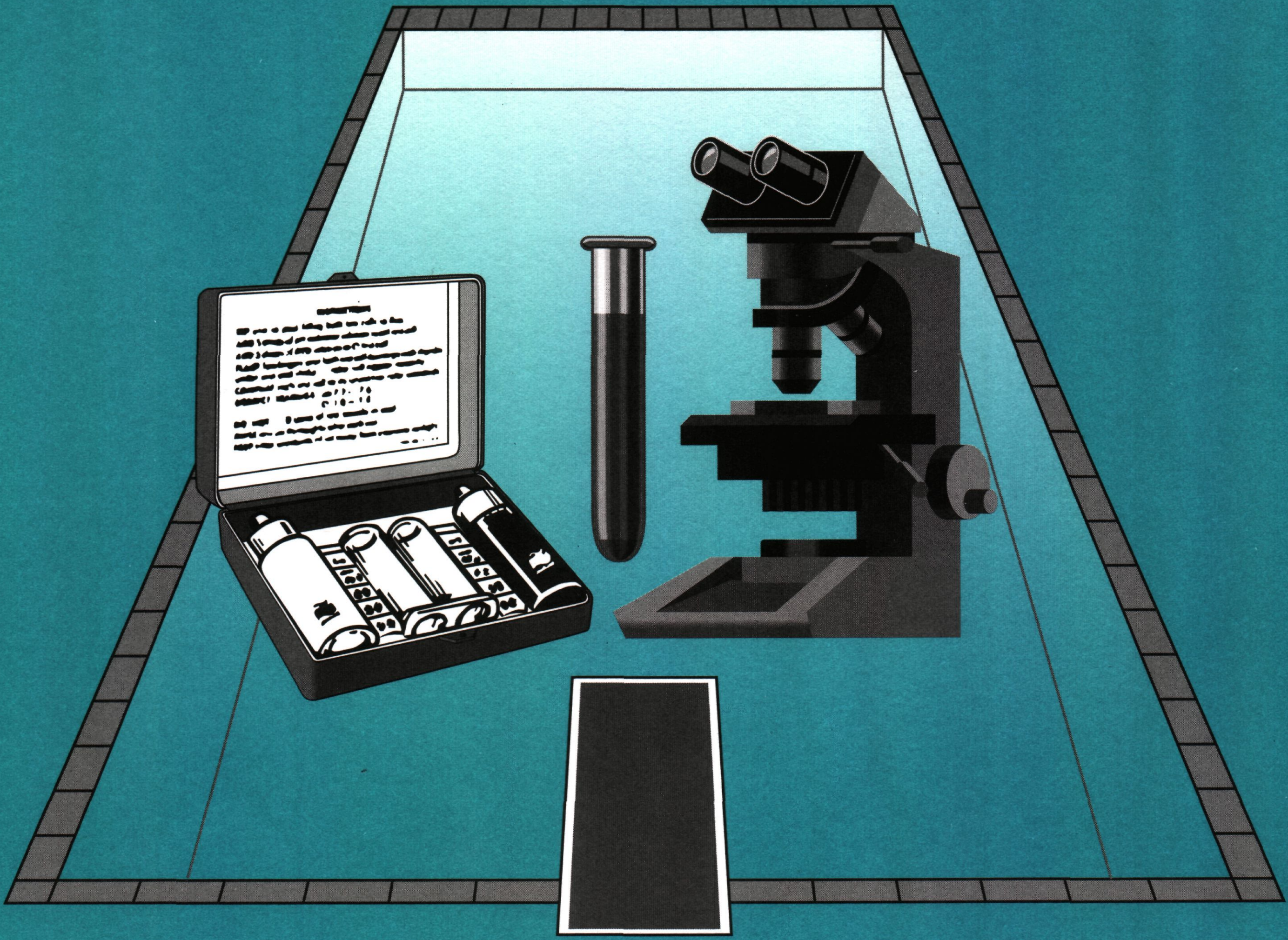

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Swimming Pool Pest Management: A Training Manual for Commercial Pesticide Applicators and Swimming Pool Operators

Category 5A

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Preface

The maintenance and operation of public swimming pools falls under the primary authority of the Michigan Department of Environmental Quality, Environmental Health Division, formerly Public Health Department. Yet, Michigan Department of Agriculture regulates the use of pesticides, which includes some chemicals used in swimming pool maintenance. Therefore, public pool operations require that the owner and operator comply with both departments' rules governing the safe and lawful operation of swimming pools.

This manual is intended to prepare pesticide applicators in category 5A, swimming pool pest management, for applicator certification under the Natural Resources and Environmental Protection Act, Act 451, Part 83, Pesticide Control. Read the introduction to this manual to understand your responsibilities for obtaining the appropriate credentials to apply pesticides safely, including some swimming pool chemicals, and how to use this manual.

Acknowledgements and Contributors

The topics selected for this manual were formulated on the basis of a critical collation and review of published reports and other pertinent data. Professional environmental health sanitarians, engineers and consultants have contributed to this publication.

The Swimming Pool/Spa Committee of the Michigan Environmental Health Association (M.E.H.A.) is the successor to the original committee appointed to formulate previous technical literature.

This M.E.H.A. committee consisted of the following: Ted Baran, Elwin Coll, Gil Daws, Bill DeHaan, Greg Folkringa, Peggy French, John Johnson, Norm Kerr, Keith Krinn, Tom McNulty, John Ruskin, Paul Sisson and Deb Werner.

This manual, *Swimming Pool Pest Management: A Training Manual for Commercial Pesticide Applicators and Swimming Pool Operators* was produced by Bill De Haan, environmental sanitarian for the Kent County Health Department, and Michigan State University Extension Pesticide Education programs, in conjunction with the Michigan Department of Agriculture and Michigan Department of Environmental Quality, Environmental Health Division. Principal participants in the project include:

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We thank the National Swimming Pool Foundation for allowing us to use portions of their *Pool-Spa Operators Handbook* for technical information and as a reference tool in preparing this manual. We also thank Rutgers University for sharing their *Pesticide Applicator Training Manual: Gaseous Antimicrobial Pest Control- 12A Water Sanitization,* Penn State, Tom Mitchell, and Ken Dettmer who contributed to the development of this manual.

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Introduction

Why Should Pesticide Applicators be Certified or Registered?

Pesticides are used to protect food and non-food crops, people, homes, swimming pools, animals, and various industrial processes. To best protect human health and the environment by assuring the safe use and application of pesticides, the Michigan Department of Agriculture (MDA) administers the certification and registration program for pesticide applicators. Certification or registration requires obtaining the knowledge necessary to purchase and safely use pesticides. Because some of the chemicals used in pool maintenance and operations are pesticides this requires persons who handle and apply them to be certified or registered pesticide applicators. The following sections explain who must be certified or registered.

Certification/Registration Requirements

The Natural Resources and Environmental Protection Act, Act 451, Part 83, Pesticide Control, requires any person who applies a pesticide product for a commercial purpose, or applies any pesticide in the course of his or her employment, or other business activity for any purpose other than a private agricultural purpose, to be either a commercially certified applicator or a registered technician. Exempt from the certification and registered technician requirements are those pesticide operations not required to be licensed by the Act and those applicators using general-use, ready-to-use pesticide products. For example, a person who works at a hospital, school, factory, golf course or an apartment complex that uses *only* a general use, ready-to-use pesticide products is not required to be a certified applicator or a registered technician. For more information, read the laws and regulations chapter of the Pesticide Applicator Core Training Manual (E-2195) or contact your local MDA office (see appendix I).

Certification of Commercial Applicators

To become certified as a commercial applicator in Swimming Pool Pest Management (Category 5A) in Michigan, you are required to successfully complete a written exam on the Core manual information from Part A (E-2195) and an exam on information found in this manual. Information found in the appendices is *not* covered on the MDA exams. Exam questions are based on information provided in this training manual developed by Michigan State University Extension (MSUE), Michigan Department of Agriculture (MDA), the Michigan Department of Environmental Quality (MDEQ), and environmental sanitarians working in the swimming pool management industry.

This manual presents basic water chemistry parameters, pest management and pesticide handling information for persons managing bacteria, fungi, algae or viruses in swimming pools, hot tubs, and spas and wading pools. This manual is self-teaching and contains learning objectives and review questions at the end of each chapter. It also explains the standards of knowledge required of registered technicians and commercial applicators for Category 5A, swimming pool pest management.

Recertification for Certified Commercial Applicators

Similar to a Michigan driver's license, applicators are required to be recertified every three years. You can be recertified by one of two methods. With one method, you can request from the MDA to take a recertification exam that shows a sustained level of knowledge in proper pesticide use. Study manuals are available from MSU. With another method, you can attend approved seminars or workshops relating to swimming pool pest management and accumulate credits over the three-year period to satisfy the recertification requirements for category 5A. For specific information on recertification, contact your local MDA regional office.

Registered Technicians

To become a registered technician in Category 5A, you must successfully pass an exam based on Part A of the Pesticide Applicator Core Training Manual (E-2195) and participate in an approved training program specific to pool pest management. To receive a registered technician application form, contact your local MDA regional office.

Registered technician status is valid for three years. At the conclusion of the three-year registration period, the technician may renew the registered technician credential by examination and refresher training, or by accumulating a specific number of reregistration credits. Credits toward reregistration are earned by attending approved workshops and seminars during the three-year registration period. A registered technician also may choose to fulfill the requirements for becoming a certified commercial pesticide applicator instead of the registered technician credential.

Suggestions for Studying This Manual

The ten chapters in this manual are designed to assist commercial applicators to meet registered technician or certification requirements. You may already know some of the material from your experience with pesticides. Self-help questions are included at the end of each chapter, but they are not necessarily the questions on the certification exam. If you have problems using the manual, please consult your county Extension agent, your supervisor or a representative of the MDA for help.

The following are suggestions for studying this manual:

1. Find a place and time for study where you will not be disturbed.
2. Read the entire manual once to understand the scope and the manner in which the material is presented. A glossary at the back of the manual defines some of the terms used in the chapters.
3. Study one chapter at a time. Read the learning objectives to determine what critical information should

be obtained from the chapter. Underline important points or take written notes as you study the chapter.

4. Answer, in writing, the review questions at the end of each chapter. Review the learning objectives and confirm that you have grasped the critical points from the text. These learning objectives and questions are intended to help you study and evaluate your knowledge of the subject.

5. When you have finished studying all of its sections, reread the entire manual once again. Review any sections that you feel you do not fully understand.

This manual is intended to help you use pesticides effectively and safely when they are needed. Review it occasionally to keep the material fresh in your mind.

CHAPTER 1

IPM AT THE POOL FACILITY

LEARNING OBJECTIVES

After completely studying this chapter, you should be able to:

- Explain the term integrated pest management (IPM).
- List pests that can live in pools.
- Name the water chemistry parameters that must be managed.
- Identify the sources of contaminants in pool water.
- Monitor pool environments.
- Explain various pool pest management control tactics.
- Explain the role of pool sampling and testing in pest and water quality management.

Pool Pests and Water Chemistry

Swimming pools and spas should be clear, sparkling bodies of water that provide recreation, fun and relaxation. These bodies of water require specific management and regular maintenance to keep them clean and safe. The pool owner/operator also has certain legal liabilities for pool safety.

Managing a swimming pool or spa requires knowledge about the types of pests that may be found in a pool environment, as well as a technical understanding of the water chemistry.

A technical understanding and constant maintenance of the water chemistry is essential for maintaining a safe and clean pool or spa. Water chemistry levels influence pest levels, and the bathers' comfort and safety. Water parameters that must be managed include:

- Organic content,
- pH,
- Total alkalinity,
- Calcium hardness,
- Temperature,
- Concentration of available disinfectant, and
- Total dissolved solids.

Pests may invade and deteriorate the quality of any environment. Microbial pests that can be introduced in pool environments include:

- Algae,
- Bacteria,
- Fungi, and
- Viruses.

Just as water chemistry influences pest levels, pest levels can influence water chemistry. Furthermore, if not controlled, microbial pests can damage equipment or create unsafe and unhealthy conditions for pool users.

Integrated Pest Management (IPM)

To manage water chemistry and control the pests that interfere with pool and spa systems, we can use a management system known as integrated pest management (IPM). IPM is the use of all available tactics or strategies to manage pests so that, in this discussion, acceptable pool and pool facility quality can be achieved economically with the least disruption to the environment. This acronym also works nicely to represent integrated pool management (IPM). IPM allows us to use all the information about an aquatic environment to keep pests in check and water chemistry balanced. When one part of this aquatic management puzzle—pests or chemistry—gets out of control, there is likely to be problems with the other.

Understanding the characteristics of the water system you manage and the pests associated with it, including their identification, life cycles, and density, is essential to a successful IPM program. Employing an IPM program allows you to methodically gather site and system information, make informed decisions, select and implement control measures, and evaluate and record the results.

Monitoring and Sampling

Monitoring aquatic environments is a continuous job and involves using testing kits as well as your senses. Watching the color and clarity of the water are indications of water characteristics and signs of pest development. Pests may not be obvious in the morning but may be detectable later the same day. The pool's odor can be an indicator of whether the water parameters are balanced or not. By monitoring the pool users, (for example asking swimmers about eye irritation) an operator can be alerted to water quality problems. Monitoring the activity and cleanliness of the pool users also provides indicators of the water's chemical needs, especially when pools are crowded or many bathers are using tanning lotions and oils. Monitoring and requiring bathers to shower before using the pool are factors in overall pool water management. Keeping track of the sanitary condition of pool facilities and buildings also factors into the potential for pool water contamination.

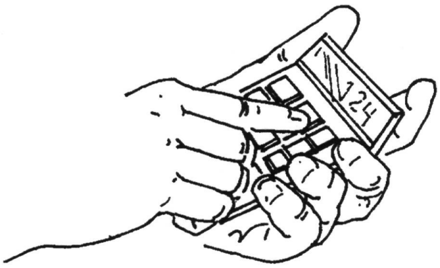
Monitoring water chemistry parameters requires a perceptive sense of smell and use of visual indicators such as turbidity. However, to specifically identify a chemical imbalance requires measurements with testing equipment. For instance, specific test kits are used to determine the disinfectant levels, pH of water, total alkalinity, total hardness, total dissolved solids (TDS), and copper and iron levels. The test kits must have fresh reagents and be kept clean to provide reliable results. The use of these kits is discussed in more detail in chapter 4.

To measure levels of disinfectants, including free available chlorine (F.A.C.), total available chlorine (T.A.C.) and combined available chlorine (C.A.C.), the D.P.D. (diethyl-p-phenylenediamine) test kit is recognized by the Michigan Department of Environmental Quality (MDEQ) as reliable if performed correctly.

Bacteriological analysis of swimming pool water determines the sanitary quality and suitability for public use. Pool water can become highly contaminated or polluted, at least momentarily, from the swimmers in it. Michigan's rules for public pools require the collection and bacteriological analysis of water samples once a week, or more often under unusual conditions as directed by the state or local health department. The frequency of sampling may vary with such factors as the amount of pool use, especially if the pool is heavily used. If possible, collect samples for bacterial analysis when swimmers are in the pool, preferably during periods of peak use. Since the maximum amount of contamination exists within approximately the first five minutes after swimmers have entered the water, it is ideal if samples are collected within this period. If the water quality under such extreme conditions is satisfactory, it is reasonably correct to state the water quality is satisfactory at other times when the bather use is less.

Specific Identification of Pests and Chemical Imbalances

Once the pool operator determines there is an upset in the chemical balance of the water—it is turbid, smells strongly of the disinfectant, or possibly there is a contaminate in the water—the cause of the poor water quality must be identified. Determining which water parameters are outside of an acceptable range and using another tool—the *Langelier saturation index*—provides the operator with information needed to balance the pool water. (The use of the Langelier saturation index is discussed in chapter 6, Water Chemistry and Pool Water Balance.) Further, the levels of disinfectant must be evaluated continually and adjusted according to current conditions. Correctly identifying a type of algae aids in the selection of the best control tactic. Also, the level and frequency of detecting contaminants gives the operator information for adjusting management practices to ensure public safety.



The pool operator must know how much water is in the pool and have a working knowledge of the pool's recirculation and filtration systems. Identifying malfunctioning equipment must be immediate. A malfunctioning filtration system may require abnormally large amounts of chemicals, while makes daily pool maintenance difficult, and leads to repeated pest problems. In contrast, under-applying chemicals may render the pool water unhealthy.

Determining Significance

Since imbalances associated with aquatic sites typically cannot adjust themselves, nor will pests leave the site, any detection of pests or improperly balanced water in a swimming pool or spa warrants immediate control action. There are legal standards of disinfectant residuals and recommended water chemistry parameters that must be maintained according to MDEQ standards. See Appendix K and Public Swimming Pool Act 368.

Selecting Management Methods

Having identified correctly a pest or water chemistry problem, the pool operator can make appropriate adjustments—taking manually or mechanical action or using chemical controls to eliminate the pest or problem. In pool management, if one parameter is out of balance, other parameters are likely to be out of balance. Thus, taking action to correct all water chemistry parameters avoids recurring or persistent problems. To anticipate the desired outcome of your corrective or maintenance actions, determine your pest management goal. Then whenever you manage a pest, you will want to achieve one or a more of these three goals:

- Prevention -- keeping a pest from becoming a problem or maintaining balanced water chemistry.
- Suppression -- reducing pest numbers or damage to an acceptable level and maintaining adequate disinfectant levels throughout the pool.
- Eradication -- destroying an entire pest population such as pathogenic organisms.

In aquatic sites, eradication is a somewhat common but a difficult goal to achieve for some pests due to the constant introduction of contaminants. However, other pests are not tolerated in a swimming pool or spa.

Evaluation and Record Keeping

Completing daily pool operation records is mandatory for complying with Michigan Pool Rules, Michigan Public Health Code, Act 368 of P.A. 1978, Part 125. In addition, keep track of pool recirculation and filtration maintenance activities to help monitor equipment performance. A sample pool operation report form is in Appendix F.

Maintaining records of commercial pesticide applications (including disinfectants, algaecides) is required by the Natural Resources and Environmental Protection Act, Act 451, Part 83, Pesticide Control and Regulation 636. For future decision making, note the results of your chemical applications. There is no specific record keeping form for pesticide applications. The records must include the name and concentration of the pesticide applied, the amount of pesticide applied, the purpose (or pest) the date the pesticide was applied, the address or location of the application, where applicable, the method and rate of the application.

Required Commercial Pesticide Applicator Record Keeping Information:

- Name and concentration of the pesticide applied.
- Amount of the pesticide applied.
- Purpose (or target pest, i.e. algae).
- Date the pesticide was applied.
- Address or location of pesticide application.
- Where applicable, the method and rate of application.

These records must be kept for a minimum of one year and be made available, upon request, to an authorized representative of the MDA during normal business hours. (Reg. 636, R 285.636.15)

Techniques Used in Pool Management

In most environments, natural and applied (human intervention) techniques are used to manage pests. Proper identification, knowledge of the pest and its density, and understanding the environment that favors pest development allows applicators to choose the right combination of techniques to manage a pest in the most economic and efficient manner. Understanding water parameters, what influences them and how to test for them will help you keep those parameters in balance.

Swimming pools and spas are artificially designed and constructed aquatic environments. Natural pest controls do not sufficiently control the microbial pest populations found in these systems. Pool facilities and pool water management require applied pest management control techniques. Applied control involves using mechanical, physical, cultural, and chemical methods to manage safe and healthy pool environments. Pool operators must be concerned not only with the pool itself, but with facilities surrounding the pool as well.

1. **Physical and mechanical controls.** Physical and mechanical controls prevent or reduce the infestation of pests or contaminants. The pool's design and construction have an influence on the likelihood of pest infestations and reproduction. Two of the most important tools are filtration equipment and multiple inlets with adequate recirculation flow that a pool operator employs to maintain clean water. When working properly, the recirculation and filtration system distribute the water evenly throughout the pool. This helps ensure water clarity. If not working properly, water clarity suffers.

Keeping pool surfaces—sides and bottom—smooth also is important to deter pests from adhering and becoming established. Daily skimming of the water's surface helps remove debris before it sinks to the bottom. To prevent leaves and other debris from entering the water when outdoor pools are not in use, use devices such as net-like screens which are pulled over pools.

Skimming is an important pool maintenance practice.

There are other issues that must be addressed. Vandalism is a costly problem that can be deterred with supervision and keeping pool enclosures and equipment rooms properly secured. To avoid chemical accidents, store pool chemicals in a cool, dry, ventilated and locked area. Safety of a pool facility requires the use of appropriate fencing, locks and gates. Further, first aid equipment and rescue equipment must be available and in good repair. See Appendix C for more information.

Keep pool chemicals stored in a cool, dry, ventilated and secured area.

Safety includes the availability of first aid and rescue equipment at the pool facility.

Remember, you must post the maximum number of pool users that the pool can handle where all swimmers can see and read it, and then enforce the bather load limit.

2. **Cultural Controls.** Sanitation is an important aspect of maintaining clean and safe pools. The pool operator must consider the entire pool complex including the pool water and structure, decks, floors, toilet, and locker room facilities, and enforce a stringent code of cleanliness to reduce pests and safety hazards.

Bather cleanliness is vital to maintain sanitary and safe pool conditions and to prevent the introduction of contaminants into the pool. Expecting cleanliness standards entails adhering to common sense provisions. These may include:

- Requiring a full-body shower with soap and warm water immediately before entering the pool water is recommended. Before entering or returning to the pool after using the toilet, bathers must shower to

Require pool users to shower with soap and warm water before using the pool to prevent contaminants from entering the pool.

remove contaminants from the body. Monitor swimmers for cleanliness, especially if tanning oils are used at the pool. Bathers must thoroughly rinse all soaps from showering and shampooing before entering the pool. Soap and shampoos upset the water chemistry.

- The pool should never be used as a bathtub or toilet. Disease organisms are introduced into the pool water when urine and feces are released into the water.
- Clothes worn in the pool should be designed for swimming. Clothes with frayed edges are not recommended. Bathing suits must be clean to prevent introducing bacteria and algae into the water.
- Street clothes or shoes should not be allowed in the pool area unless a person with official duties requires entry. This limits the dirt and debris tracked across the deck of the pool.
- Keep swimmers out of the pool if they have skin cuts, blisters, open sores, a cold, inflamed eyes, or any infection of the eyes, ears, nose or throat. Do not tolerate spitting into the pool or clearing of noses— these habits contaminate the water.

Maintaining good water quality is easier if pool operators and pool users keep contaminants out of the pool. Also, it is important to keep glass, soap, papers, sharp toys or anything else that might affect the safety of the pool users out of the pool area. Although it is permissible to serve and consume food within pool enclosures, the owner or operator of the pool should have a staff member monitor the area to maintain safe and sanitary conditions.

3. **Chemical Controls.** Pesticides are naturally derived or synthetic chemical controls that kill, repel, attract, sterilize, or otherwise interfere with the normal behavior of pests. In the pool management industry, many of the chemicals used in pool operations are referred to as disinfectants or sanitizers. These products control microbial organisms that are introduced into pool water. Certain chemicals are labeled for the control of specific pests. For instance, products used to kill algae are called algaecides. When a chemical is used for the purpose of killing or altering a pest, it must have an EPA-approved label and an EPA (Environmental Protection Agency) registration number.

The elimination or control of infectious organisms requires maintaining adequate disinfectant levels in all parts of the pool water. Chemical controls are mandatory for operating a safe and healthy pool in Michigan. The Michigan Public Swimming Pools Rules of Act 368, P.A. 1978, Michigan Public Health Code, sets forth several specific requirements regarding operational practices and procedures for public swimming pools. A set of these operational guidelines are printed in Appendix K. Refer to a complete copy of the Act to know the requirements for compliance.

In addition to pesticides used to kill algae, fungi, bacteria, or other pests found in pool water, there are chemicals used for maintaining pool water quality by balancing the water chemistry parameters. Water chemistry parameters that must be managed include organic content, pH, total alkalinity, calcium hardness, temperature, and total dissolved solids. The chemical maintenance of these parameters is discussed in chapter 6, Water Chemistry and Pool Water Balance.

CHAPTER 1

Review Questions

IPM at the Pool Facility

Write the answers to the following questions, then check your answers with those in the back of the manual.

1. Which of the following organisms can be pests of swimming pools?
   a. Algae
   b. Bacteria
   c. Fungi
   d. Viruses
   e. All of the above.

2. Circle all of the water chemistry parameters that a swimming pool manager must monitor and maintain:

   pH Organic matter Total Alkalinity
   Calcium hardness Temperature
   Disinfectant levels Total dissolved solids

3. Bathers that use the swimming pool can introduce a constant supply of contaminants to the pool water. True or False?
   a. True
   b. False

4. Monitoring pool environments to maintain clean, safe water includes:
   a. monitoring the pool users.
   b. using test kits.
   c. sending samples to a laboratory.
   d. All of the above.

5. List some physical and mechanical controls that prevent or reduce the infestation of pests or contaminants in pools.

6. Sanitation of the entire pool complex, including the pool water and structure, decks, floors, toilet, and locker room facilities, is an important aspect of maintaining clean and safe pools. True or False?
   a. True
   b. False

7. To measure levels of disinfectants, including free available chlorine (F.A.C.), total available chlorine (T.A.C.) and combined available chlorine (C.A.C.), which test kit is recognized by the Michigan Department of Environmental Quality as reliable, if used correctly?

CHAPTER 2

PESTS OF POOLS

LEARNING OBJECTIVES

After completely studying this chapter, you should be able to:

- List ways that microorganisms are introduced into swimming pools and spas.
- Explain how pool water has led to the spread of diseases.
- Define pathogen.
- List illnesses associated with spa pools/hot tubs.
- Describe the types of injury or damage caused by algae in pool water.
- Explain what preventative measures can reduce the likelihood of algae.
- Understand what factors influence microbial growth in pool water.
- Explain what the Gram stain test indicates.
- Compare algae, bacteria, viruses and fungi.

Disease Transmission

Microorganisms are continuously introduced into swimming pool water by swimmers, rain, dust, dirt, and organic materials such as leaves, and grass. In addition, dirty decks, toilets, locker room facilities, bathers, and personal items are potential disease transmitters. To combat these sources of contamination, the pool operator must be concerned with the cleanliness and sanitation of the entire facility.

The amount of microbial content in the pool is influenced by the pool water's organic content, pH, temperature, ambient light, turbidity, salinity, and especially the concentration of available disinfectant. Waste products like urine, fecal material and body oils contain numerous organisms that may cause diseases or infections. Inadequate residuals of a halogen-based disinfectant in the pool, increased bather loads, use of the pool by infected persons, and imbalances in the water chemistry greatly increases the potential for human illness.

Proper control of disease organisms is mandated by state and local health laws that require swimming pools be maintained to prevent the spread of diseases and infections that affect the skin, eyes, ears, nose, throat, and digestive system. Because swimmers often swallow pool water inadvertently, it is essential that the bacteriological water quality closely resemble drinking water.

Infectious diseases have been associated with swimming pools and spa/hot tubs or therapy pools. The water can carry **pathogens** (disease causing microorganisms) to the swimmer's gastrointestinal tract, skin, eyes, ears, nose, throat, and other areas of the body where bacteria can easily grow. For example, such bacteria as *Salmonellae, Shigellae, Campylobacter sp., Giardia sp.,* etc. have been associated with gastrointestinal illness when swimmers swallowed contaminated water.

Aside from gastrointestinal illnesses, infections acquired from pools include *Chlamydial conjunctivitis* (eye infection), pharyngonjunctival fever, coxsackie viruses, planter warts, athlete's foot and swimming pool granuloma. Illnesses associated with hot tubs include folliculitis, dermatitis, conjunctivitis (eye infections), pneumonia (lung infections), Otitis externa and Otitis media (ear infections), urethritis due to the bacteria of the *Pseudomonas* genus, especially *P. aeruginosa,* and Pontiac fever (a form of Legionnaire's disease).

Swimming Pool Pests

Algae

Algae are a group of aquatic organisms containing chlorophyll, a green pigment, that enables them to produce food from water, air, and sunlight by a process known as photosynthesis. Algae are single celled organisms and may appear in long strands. Algae slimes may be free-floating on the surface of the water, or they may attach themselves to any wetted surface of the pool that is exposed to air and light.

Although there are many kinds of algae, there are three general types usually referred to by their color: green, black, and yellow. The most common is the free-floating green algae, and it is the most easily controlled by chemical treatments. Black and yellow algae normally attach themselves to pool surfaces such as walls, floors, or steps. Once algae adheres to a surface, it is very difficult to remove.

Algae are commonly found in outdoor pools and occasionally in indoor and spa pools. Algae are not considered responsible for human diseases, but their presence in pool water is troublesome and objectionable. For example, algae may:

- Give the pool water a turbid and dirty appearance.
- Cause bathers to itch.
- Cause the surfaces around and in the pool to become slippery and unsafe.
- Increase chlorine demand.
- Absorb pesticides and reduce treatment effectiveness.
- Give the pool water a disagreeable odor or taste.
- Clog water-filtering systems.

Algae is introduced into pool water by wind-borne debris, rain, floating debris, bathing suits, or the water source from which the pool is filled. The levels of sunlight, pH, temperature, bacteria content, and disinfectant residual all contribute to the presence and growth of algae. When water temperatures and nutrients reach favorable levels, certain algae multiply very rapidly. Some can cause algal bloom or "scum," which may seriously affect the water quality.

Properly designed and operated swimming pools can greatly reduce the potential of algae growth. Suitable water disinfection and filtration equipment, multiple inlets with adequate recirculation flow, and smooth pool surfaces are important features that contribute to the success of pool pest management. For outdoor pools, shading the water from the sun may reduce the likelihood of algae.

Good pool operation is essential for preventing algal growth. Operate pool treatment facilities on a 24-hour basis to insure complete filtration and disinfection of the pool water. Keep disinfectant levels high enough at peak bather usage periods, and keep the filter clean of grease, oils, and debris to help prevent algae growth. Avoid high pool water temperatures to lessen algae growth. Keep pool surfaces (walls, floors, coping, decks) clean and in good repair. Brush or vacuum these areas frequently. Keep pool decks and walkways clean and properly drained. Frequent scrubbing is advisable with a final sanitizing rinse of disinfectant.

With proper chlorination and water balance, algae will not become a problem. Unfortunately, control is lacking from time to time and algae becomes established in the pool. When this occurs **algaecides** can be used—chemicals that prevent and control algae. Because some chemicals work more effectively on one type of algae than another, it is important to keep records of your applications and the results. Use the records for making future decisions on product selection and application rates.

Yellow algae can be removed by brushing. Black algae need to be brushed with a stainless steel brush which scores the algal cells outer wall thereby exposing it to chlorine that kills it. When large accumulations of algae form, it may be necessary to drain the pool and scrub all exposed surfaces with a 200 ppm chlorine based solution. The solution can be made by adding 1/8 cup (1 ounce) of household bleach to 2 gallons of warm, clean water. If the pool cannot be drained, the addition of an algaecide designed to kill black, yellow, or green algae must be made along with physical brushing to remove the dead algae. Normally, when the pool is full of water, a copper or polymer-based algaecide is used to kill algae in the pool water.

Bacteria

Bacteria are microscopic, one-celled organisms that lack chlorophyll. Four hundred million (400,000,000) of these cells equal the size of one grain of granulated sugar. When bacteria are magnified 1,000 times, they look no bigger than a dot on this page.

Bacterial cells reproduce by dividing in half (fission) to become two identical cells. Under ideal conditions, some bacteria reproduce as often as once every 15 to 30 seconds. One bacterium could become 70 billion bacteria in only 12 hours.

Bacteria are divided into two major groups based on a staining technique called a **Gram stain**. Those that stain a violet color are called **Gram positive**; examples are the bacterium that causes tetanus (*Clostridium tetani*) and the bacterium that causes acne infections (*Staphlyococcus aureus*). Those that stain another color (besides violet) are called **Gram negative**; examples are the bacterium that causes typhoid (*Salmonella spp.*), and a bacterium that can break down or contaminate a number of living and nonliving things (*Pseudomonas aeruginosa*).

In addition to their staining characteristics, bacteria can be grouped based on other characteristics. All of the thousands of species of bacteria have one of three general forms: spherical (round), rod-shaped, or spiral. Some

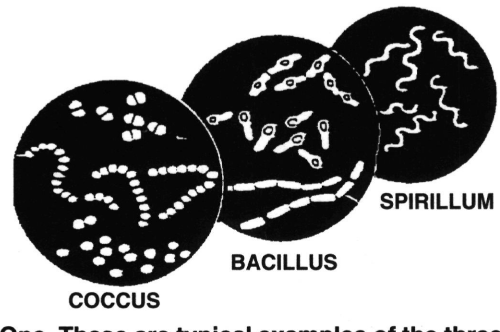


Figure One. These are typical examples of the three groups of bacteria. Illustrations from "Modern Biology," by T.J. Moon, J.H. Otto, and A.Towle, Henry Holt and company, Inc. 1960.

bacteria require air (aerobic bacteria) while others grow only in the absence of air (anaerobic bacteria). Bacteria grow in any water that contains organic matter or certain inorganic compounds that serve as nutrients.

Although bacteria are often considered a problem, we do benefit from some forms of bacteria. For example, *Bacillus thuringiensis,* commonly called Bt, is the most widely used microbial insecticide. Bt is used to control some pests, like mosquitoes and gypsy moth larvae.

Unfortunately, the bacteria found in swimming pools is generally dangerous and should be controlled. Certain bacteria produce poisonous substances (toxins) that can cause diseases, such as lockjaw, or food poisoning in humans. Other bacteria produce enzymes that can foul surfaces that we contact daily or contaminate equipment and food products.

Bacteria in pool water are managed by maintaining a minimum level of disinfectant throughout the volume of pool water. Disinfectants and chlorination are discussed in chapter 3, Pool Water Disinfectants and pH, and chapter 7, Chlorination of Pool Water.

Viruses

Viruses are parasitic microorganisms that live and reproduce only inside the living cells of their selected host. Viruses are about 1,000 times smaller than bacteria and are seen only with the aid of an electron microscope.

A virus enters a living plant or animal cell and reproduces itself within that cell. It usually destroys the cell and must enter another cell to survive. A virus has no means of movement. It depends on air, water, insects, humans, or other animals to carry it from one host to another. Swimming pool water serves as a perfect carrier for viruses to reach new hosts. Some viruses survive away from the host for many hours or days when in organic material such as scabs, blood, and body wastes.

Some of the diseases of humans caused by viruses include influenza and hepatitis A. Viruses are killed in pool water by filtration and sanitizing with a minimum level of disinfectant throughout the volume of pool water. Disinfectants and chlorination are discussed in chapters 3 and 7.

Fungi

Fungi are a large group of plant-like microorganisms that live by feeding on either living or dead organisms (parasites or saprophytes). Fungi have no roots, stems, or leaves and require moisture and oxygen for growth. Fungi differ from algae in that they cannot make their own food because they lack the green plant pigment chlorophyll. Some fungi, such as yeast, occur as single cells that require a microscope to be seen. Others, such as mushrooms, are quite large. Over 100,000 species of fungi have been identified. Fungi and bacteria are often found together in nature.

Fungi reproduce in several different ways but all require moisture and oxygen. Some reproduce from cellular fragments of the fungal organism. Others produce spores that function like seeds of higher plants. Spores of fungi are not as resistant to chemicals, heat, or drying as are spores of bacteria.

Some fungi cause diseases in humans. Coccidiosis and histoplasmosis are fungal diseases caused by inhaled spores that infect the lungs and other internal organs. Ringworm is an infection of the skin and nails caused by fungi and can be transmitted by direct contact with contaminated towels, combs or other shared items.

Fungi in pool water are killed by filtration and maintaining a minimum level of disinfectant throughout the pool water. Disinfectants and chlorination are discussed in chapters 3 and 7.

Figure two. Algae, though among the simplest plants, are represented by a rich variety of forms.

CHAPTER 2

Review Questions

Pests of Pools

Write the answers to the following questions, and then check your answers with those in the back of the manual.

1. List ways that microorganisms are introduced into swimming pools and spas.

2. Pool water has led to the spread of diseases between people.
   a. True
   b. False

3. What human body parts can be affected by pathogens, primarily bacteria, found in pool water?

4. Name several conditions that influence and possibly enhance the growth of microbial organisms in pool water.

5. Which illnesses have been associated with spa pool/hot tubs?

6. What kind of problems can algae cause when it is in pool water?

7. What preventative measures can reduce the likelihood of algae occurring in pool water?

8. Algal development is controlled in pools primarily because it causes health problems for people.
   a. True
   b. False

9. List four diseases associated with the gastrointestinal tract when swimmers swallow contaminated water.
   1.
   2.
   3.
   4.

10. Where else other than in the pool water, can bacteria be found at a pool facility?

11. Bacteria reproduce:
    a. sexually.
    b. by dividing in half (fission).

12. The Gram stain test is used to:
    a. identify the two major groups of bacteria.
    b. kill most forms of bacteria.

13. Viruses:
    a. are bigger than bacteria.
    b. live in the living cells of their host.
    c. can move to a new host using their own locomotion.

14. Fungi can make their own food using chlorophyll. True or False?
    a. True
    b. False

CHAPTER 3

Pool Disinfectants and pH

LEARNING OBJECTIVES

After completely studying this chapter, you should be able to:

- Define oxidation and sanitization.
- Name 3 forms of chlorine-based disinfectants used for sanitizing pool water.
- List the minimum safety requirements for chlorine gas use.
- Explain what a stabilizer does for chlorine.
- List 4 types of sanitizers or oxidizers approved for use in public pools.
- List the disadvantages of using ozone, ultraviolet light, or silver-copper ionization as a disinfectant.
- Know the impact of low or high pH levels on pool water.
- Understand how the addition of various chemicals changes the pH of the pool water
- Explain two methods for controlling pH.

Because of waterborne outbreaks of typhoid, cholera, and hepatitis, health scientists have emphasized the need to treat water that is used for human consumption or recreation. Chlorine and a few other chemicals, when used properly, act as disinfectants and prevent the spread of several communicable diseases.

The most common method of disinfection is with chlorine-based (chlorinated) products. There are several **disinfectants** approved by public health officials for use in public swimming pools to control disease and to maintain specific sanitation standards. These disinfectants are considered pesticides and must be registered for use by the EPA and used according to their label. In addition, to be used in Michigan pesticides must be registered by the State of Michigan through the Department of Agriculture.

Other types of chemical disinfectants are available, as well as non-chemical methods of disease control. Used *alone*, some of these methods are not approved by public health officials for public pool maintenance. Ozone, iodine, ultraviolet light, and silver are among this group of unapproved sanitizing products. However, these methods could be used in conjunction with a chlorinated product, or equivalent, to provide acceptable and adequate pool sanitation.

When handling chemicals, always wear personal protective equipment (PPE). Many of the chlorine-based chemicals have extreme pH properties—very acidic or very alkaline—and can cause severe injury to the handler if contact is made with unprotected skin. When using pool chemicals, remember the following:

1. When handling chemicals wear protective gloves, eyewear and clothing.
2. Read the chemical label before opening the package. Understand the directions for use and safety information before starting an application.

Store chemicals in their original containers in a cool, dry and secured location.

3 Chemicals used for disinfection must be continuously fed into public pools by an automatic feeding system.

4. Chemicals are mixed into the target body of water. Never add water to a chemical.
5. Never mix chemicals with other chemicals unless specified and permitted by the labels of each.
6. Store chemicals in their original containers in a cool, dry and secured location.

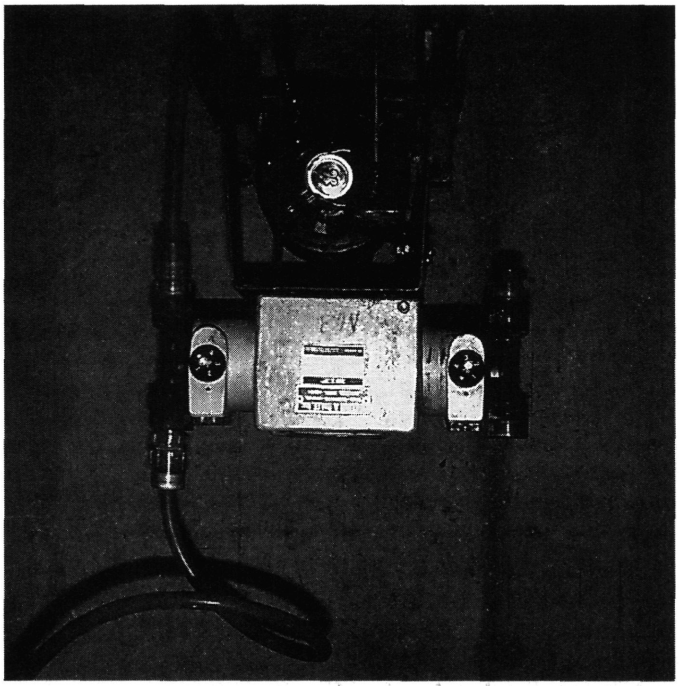
Chlorine-Based Pool Disinfectants

When chemicals containing chlorine are added to water, an active chemical is formed called **hypochlorous acid (HOCl)**. The HOCl molecule is an extremely powerful **oxidizing** (capable of destroying or "burning up" the organic debris) agent. It destroys harmful organisms such as bacteria, algae, fungi, and viruses, along with impurities too small to be removed by filtration.

- The action of HOCl that destroys harmful organisms is called **sanitization**.
- The action of HOCl that destroys the impurities not removed by filtration is called **oxidation**.

Using a chlorine-based chemical is considered a type of pesticide application or pesticide treatment. Before using any chemical, read the label on the container, the material safety data sheet, and all pertinent information.

Any chlorine-based product used in a public swimming pool must be labeled for that purpose and *approved by the MDEQ*. Chemicals used for disinfection must be continuously fed into the pool by an automatic feeding system. Adding chlorine-based chemicals to a pool by hand (hand feeding) is **NOT** allowed.



Chlorine-based chemicals must be fed continuously into the pool by an automatic or semi-automatic feeding system.

Chlorine Gas [Cl_2]

The laws and liability surrounding the use of chlorine gas make it one of the most expensive disinfectants to use. Because of the extreme risks involved with chlorine gas, its use is *not* justified for swimming pool operations when alternative disinfectants are available. Using chlorine gas for pool disinfection is an out-dated method and no longer recommended.

Chlorine gas is extremely toxic. Chlorine in gas form is 100% available chlorine by weight. The gas is pale green in color, heavier than air and is deadly if improperly used, handled, or stored. Chlorine gas is packaged and contained in pressurized steel cylinders. Chlorine in gas form, has a pH of 0 to 2—extremely acidic. Therefore, a tremendous amount of **soda ash** (pH increaser) is needed to control the pH of the water when it is chlorinated with chlorine gas.

No new or refurbished gas chlorine systems can be installed without MDEQ approval. There are fewer than six such systems in use within Michigan, and they are being replaced with safer, more economical methods of disinfection. Although, existing chlorine gas systems are allowed to continue operation, operators are encouraged to replace them with safer chlorinating systems.

The following is an overview of some of the minimum safety requirements for chlorine gas use:

1. Chlorine gas cylinders must be chained or secured to a rigid support to prevent tipping.
2. Chlorine gas should always be stored within a fire resistant room or building.
3. The storage room must be designed to keep the tanks and chlorinator separated from any other equipment or chemicals.
4. The storage room or building must have proper ventilation capable of a complete air change within one (1) to four (4) minutes.
5. An approved self-contained air supply (gas mask) must be kept just outside the storage room at all times.
6. Check the chlorine gas cylinder and the chlorinator for leaks daily. While wearing personal protective equipment (PPE), including a self contained air supply mask, use a small amount of household ammonia on a cloth and rub over the equipment hose connections and regulator. In the presence of a chlorine leak, this produces a white vapor.
7. Use a new lead gasket each time a new cylinder is put into service to prevent possible gas leaks.

The sun's ultraviolet rays quickly degrade chlorine gas. In bright sunlight in a two hour period, 97% of the chlorine can be degraded from the swimming pool. A water stabilizer, such as cyanuric acid, can be used to make the chlorine last longer.

Calcium Hypochlorite [$Ca(OCl)_2$]

Calcium hypochlorite [$Ca(OCl)_2$] is 65% by weight available chlorine. It is available in granular, stick, and tablet formulations. Calcium hypochlorite has a pH of 11.8—very basic. Therefore, when using calcium hypochlorite as your disinfectant, the pool water requires **muriatic acid** or **sodium bisulfate** to lower the pH of the pool water to the desirable range of 7.2-7.6.

If used for a 'shock treatment' (raising the disinfectant above normal maintenance levels), calcium hypochlorite must first be dissolved in water, then applied into the pool as a liquid. If directly applied to the pool as a granular product, cloudiness of the water may result. Apply stick and tablet formulations only through an automatic dispenser. The sun's ultraviolet rays also degrades this product in a short period of time.

Calcium hypochlorite must be kept in a dry cool area, free of contamination. If this chemical comes in contact with an organic compound, fire could result. If a fire occurs, the smoke (gas) is very dangerous.

Sodium Hypochlorite [NaOCl]

Sodium hypochlorite [NaOCl] is a liquid chlorine. It is a clear, slightly yellow material providing 10% to 15% available chlorine (1 lb. of chlorine per gallon). This liquid chemical has a pH of 13 and causes a slight increase in the pH of the pool water. To maintain proper pH levels in the pool water when using sodium hypochlorite, add muriatic acid or sodium bisulfate.

Sodium hypochlorite is considered the best choice for 'shocking' (quickly raising the disinfectant above normal maintenance levels) swimming pools, sanitizing decks, and shower/locker rooms. It is more economical and safer than other chlorine-based disinfectants. Sodium hypochlorite is not stable in storage and gradually loses strength. If stored in a dark cool room, it has a one-month shelf-life.

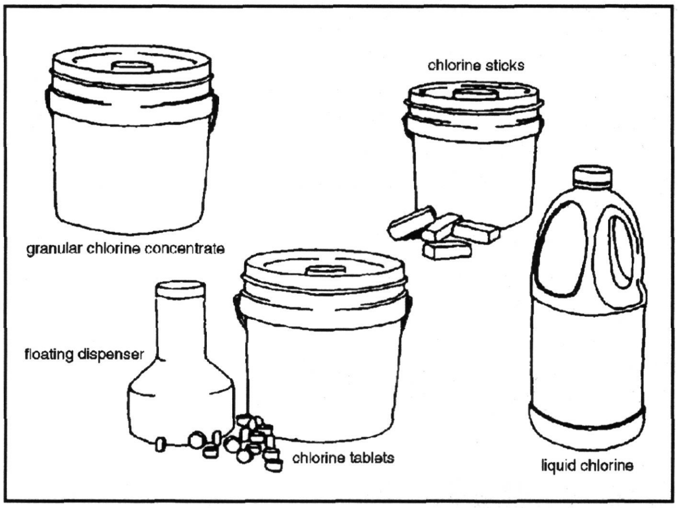
The sun's rays also degrade sodium hypochlorite. Unless a chlorine stabilizer is used in conjunction with the sodium hypochlorite, it is not considered economical for use in outdoor swimming pools.

When sodium hypochlorite is part of your pool maintenance program, it is recommended to:

- Store only a 30 day supply of sodium hypochlorite.
- Keep the chemical in a cool dry area, out of direct sunlight.
- Always personal protective equipment when handling the chemical.
- Immediately wash off any chemical splashed on the clothing or skin.

Chlorinated Isocyanurate (stabilized chlorine)

Chlorinated isocyanurate is available in three forms—granular, tablet, and stick. The granular form is called **dichloro-isocyanuric acid** and contains 55% or 62% available chlorine. The stick and tablet forms generally contain 89% available chlorine and are called **trichloro-isocyanuric acid**.



Chlorine is available in granular, tablet, stick, and liquid form.

Dichloro-isocyanuric and trichloro-isocyanuric are both "stabilized chlorines." The isocyanurate portion of the product is the **stabilizer**, sometimes called the conditioner. The stabilizer protects the chlorine from ultraviolet (UV) rays of the sun, allowing the chlorine to last longer.

The dichloro-isocyanuric acid granular material with 55% active chemical remains fairly stable once in the pool water. The 62% dichloro-isocyanuric acid formulation must be labeled as an oxidizer and is not as stable as the 55% material. Dichloro-isocyanuric acid has a pH of 6.9 and should not affect the pH of the pool as much as other products. It is very slow to dissolve, especially in water below 76oF. This is because the cyanuric acid component acts as a "blanket," surrounding each chlorine molecule, protecting it from the sun and allowing the chlorine to dissolve slowly. Thus, chlorine is more consistently available in the water.

Trichloro-isocyanuric acid sticks and tablets can only be fed into the pool water by a pressure feeder approved by the MDEQ and National Sanitation Foundation (N.S.F.). These sanitizers cannot be placed in the skimmers or hair and lint strainer as a means of feeding (application).

Cyanuric acid has no chlorine content. Yet, by maintaining a cyanuric acid concentration level of 30-40 ppm in pool water, any chlorine product will last up to four times longer. This concentration is measurable by using a test kit. The public health department has set the recommended level of cyanuric acid at 30-80 ppm. Routinely test cyanuric acid levels to insure the concentration remains within recommended guidelines. Cyanuric acid levels can be increased in a pool, but cannot be decreased without either adding specific chemicals or draining the pool and adding new water.

Cyanuric acid products are not recommended for indoor pools and spas, since the need for chlorine protection from the sun is not a concern.

NEVER condition or stabilize pool water with cyanuric acid when using bromine as a sanitizer. Cyanuric acid and bromine are not compatible chemicals.

Lithium Hypochlorite (LiOCl)

Lithium hypochlorite (LiOCl) is a fairly new product in the field of pool water disinfectants. It contains only 35% available chlorine, is more expensive than most chlorinated products, and has a pH of 10.7. The addition of lithium hypochlorite to pool water increases the pH of the water. Lithium hypochlorite has excellent stability and works well in "hard" pool water without causing cloudiness.

Operators must take the same safety precautions when using lithium hypochlorite as when using calcium hypochlorite. Lithium hypochlorite can be stabilized by using it in combination with cyanuric acid, but this makes the end product more expensive.

Bromine-Based Pool Disinfectants

Bromine and Hypobromous Acid (HOBr)

Bromine is a liquid in its pure, elemental form. Only bromine compounds are available for pool water disinfection since the pure form is too hazardous to handle. When bromine compounds are added to water, the addition or presence of an oxidizer is required to form hypobromous acid (HOBr) and hypobromite ions (OBr-). **Hypobromous acid (HOBr)** is the active oxidizing (killing) form of bromine that controls bacteria, algae, and other microorganisms. **Hypobromite ions (OBr-)** are a relatively inactive form of bromine.

For pool sanitation, bromine compounds are sold in two solid formulations. There is a two-part bromine system consisting of a bromide salt, which when dissolved in water, requires the addition of a separate oxidizer that activates it. There also is a one-part stick or tablet bromine formulation that contains both bromine and an oxidizer and is dispensed by an erosion-type feeder. Bromine is commonly used in tablet form. Bromine formulations usually contain 62% bromine and 27% chlorine (remember, chlorine is an oxidizer).

Bromine formulations have a pH of 4.0 – 4.5, which lowers the pool water's pH. Therefore, soda ash must be used in conjunction with bromine to adjust the pH of the pool water.

Bromine is not as effective in oxidizing organic matter as chlorinated products especially outdoors where ultraviolet (UV) rays quickly destroy bromine residuals. To date, there is no UV stabilizer for bromine.

All of the chemicals discussed so far are approved by MDEQ for use as disinfectants of public bathing waters. Contact your local MDEQ about other chemicals used as sanitizing agents to determine appropriate uses.

Other Types of Sanitizers or Oxidizers

In addition to chlorinated chemicals and bromine, there are other disinfectants and disinfectant devices used in pool maintenance operations.

Iodine

Potassium iodine is a white, crystal chemical. This chemical needs an oxidizer, such as hypochlorite, to react with organic debris and bacteria. Iodine does not react with ammonia, bleach hair or bathing suits, or cause eye irritation, but it can react with metals producing greenish-colored pool water.

Ozone

Ozone (O_3) is a gas. Ozone is an effective germicide with 50% greater oxidizing activity than chlorine. Ozone produces no residuals since unconsumed ozone gas reverts to oxygen (O_2). Ozone does not effect the pH of the pool water.

Ozone systems work in conjunction with the filtration system. Ozone is fed into the pool by a mechanical device. All ozone units, at the time of this printing, must be used in combination with a conventional disinfecting system to meet MDEQ requirements.

Ozone has a mild odor. It can cause eye, nose, skin, and respiratory problems at a concentration of .05 – .1 ppm, especially in a poorly ventilated area. There are two methods of producing ozone—UV (ultraviolet), and Corona Discharge. Its use is tightly regulated to assure bather and operator safety. MDEQ approval is required prior to ozone equipment installation.

Summary Disinfectant Table

	*Gase Chlorine	Sodium Hypochlorite	Calcium Hypochlorite	Lithium Hypochlorite	Dichlor	Trichlor	Bromine
% Available Chlorine	100%	12-15%	65-70%	35%	56% or 62%	90%	94% HOBr in water pH 7.5
pH effect	Lowers (pH >1.0)	Raises (pH 13.0)	Raises (pH 11.8)	Raises (pH 10.7)	Neutral (pH 6.9)	Lowers (pH 2.9)	Lowers (pH 4.0-4.5)
Lost to sunlight	Yes	Yes	Yes	Yes	No	No	Yes
Physical Appearance	Gas	Liquid	Granular & Tablet	Powder	Granular	Granular & Tablet	2-part solid or Tablet

Ultraviolet

Ultraviolet (UV) radiation is a means of killing bacteria. Pool water passes by the ultraviolet light that acts as a bactericide. It is not a new concept in sanitizing. Ultraviolet and ozone systems have been used in Europe for many years.

The success of the UV system is based on water clarity. If the water is cloudy, the rays of the ultraviolet are screened and therefore not as effective. The greatest problem that health departments have with ozone and ultraviolet systems is a bactericidal (disinfectant) residual cannot be maintained and that these systems have little or no effect on algae. Therefore, UV systems are approved for use only in conjunction with conventional disinfection systems.

Electrolytic Cells

Electrical devices—chlorine generators—were developed to manufacture chlorine. Chlorine is manufactured by electrolysis of sodium chloride (NaCl, salt) that is dissolved in water. This process also produces sodium hydroxide (NaOH). When chlorine gas (Cl_2) and sodium hydroxide come in contact with each other, they form sodium hypochlorite (NaOCl), or what is commonly called liquid chlorine. Units currently available on the market generally have very limited chlorine output. Because of this, multiple units may be required to produce desired residuals.

Silver-Copper Ionization

Sanitizing can be accomplished by using an ionizing unit that introduces silver and copper ions into the water by electrolysis, or by passing an electrical current through a silver and copper electrode. The limiting factors in using this system in the pool and spa industry are cost, a slow bactericidal action and potentially high contaminant levels caused by bather loads. Also, when using this system, if the proper parameters of water chemistry are not maintained, black spots form on pool surfaces. To insure that all debris in the pool has been oxidized and the harmful bacteria destroyed, an approved chemical disinfectant must be used in conjunction with an ionizing unit.

Flocculents

Aluminum sulfate ($Al_2(SO_4)_3$), is commonly used as a filter aid and coagulant (gathers and precipitates suspended matter), as well as a settling agent for cloudy water. Aluminum floc is a white gelatin-type substance that attaches itself to free floating matter found in water. This creates a larger, heavier particle that settles to the bottom (precipitates) of the pool or may be captured on the surface of the filter. The layer of accumulated debris can then be vacuumed.

There are several types and styles of flocs and clarifiers on the market, and all aim for the same goal. Always check the filter pressure before adding a flocking agent to any type of filter. The pressure inside the filter will build rapidly after the flocculent is added. When the pressure inside the filter becomes 10 – 12 lbs. (psi) greater than normal, shut down the system and "backwash" the filter to waste. Backwashing (process of cleaning a pool filter by reversing the flow of water through it), or adding the flocculent may need to be repeated several times before acceptable water clarity is achieved.

Sequestering Agents

Pools with high iron content require a sequestering agent as part of their routine water treatment. By "coating" or chemically reacting with the ion, a sequestering agent increases the ability of the water to hold the mineral in solution instead of precipitating out of the solution. When minerals precipitate out of the water, stains form on walls and floors of the pool.

pH

When a water molecule (H_2O) breaks down, a portion of it breaks into electrically charged particles of hydrogen ($H+$) called hydrogen ions. The remainder is broken down into hydroxyl ions ($OH-$). The pH reading is a measure of the hydrogen ion ($H+$) concentration in the pool water. The pH scale ranges from 1-14, with 7 being neutral. Anything with a numerical value less than 7 is said to be acidic and a numerical value greater than 7 is considered alkaline. pH readings also can be described as the acidity-alkalinity relationship. A change in pH of 1.0 (such as from 7.0 to 8.0) represents a tenfold change in the ion concentrations. For example, the hydrogen ion concentration of water with a pH of 7.0 is ten times that of water with a pH of 8.0, and is 10 x 10, or 100 times greater than that of water with a pH of 9.0.

When certain chemicals are dissolved in water they react to form either more hydrogen ions or hydroxyl ions. Chemicals that produce hydrogen ions ($H+$) are called "acids." Chemicals that produce high concentrations of $H+$ ions are considered strong acids, while those producing lower concentrations of $H+$ ions are weak acids.

Chemicals that produce hydroxyl ions ($OH-$) in the water are labeled as "alkalines" or "bases." Again, chemicals that produce high concentrations of hydroxyl ions are strong bases while those that produce lower concentrations are weaker bases.

The pH of water is affected by the acidic or alkaline chemicals dissolved in it. Hypochlorite solutions, soda ash, and sodium bicarbonate raise the pH. Chlorine gas, alum, muriatic acid, cyanuric acid and sodium bisulfate lower the pH.

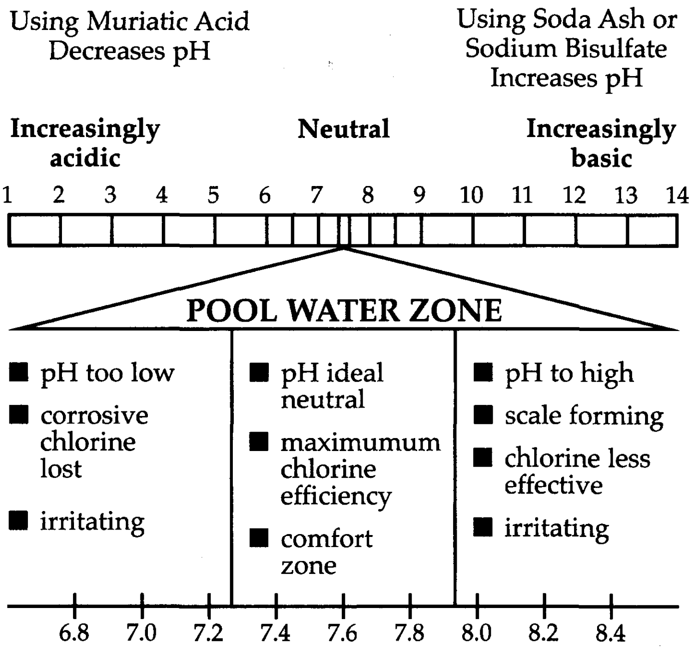
Chemicals that Cause an *Increase* in pH

- Hypochlorite solutions
- Soda ash
- Sodium bicarbonate

Chemicals that Cause a *Decrease* in pH

- Alum
- Muriatic acid
- Cyanuric acid
- Sodium bisulfate
- Chlorine gas

THE EFFECT OF pH ON POOL WATER



Significance of pH

The pH of the water greatly influences certain chemical reactions, such as those involving chlorine and bromine. Since HOCl and HOBr are acids, they can be neutralized with alkaline materials and their effectiveness decreased. These acids are said to be pH sensitive. As the pH of the water increases (becomes more alkaline), the effectiveness of chlorine and bromine decreases. For example, the disinfecting action of chlorine in water with a pH of 8.0 is only one-fourth as fast and effective as chlorine in water with a pH of 7.0.

The effectiveness of chlorine and bromine depends upon the respective proportions of available hypochlorous and hypobromous acids, which, in turn, depends upon the pH of the treated water. Table 3.1 outlines the percent of active and inactive forms of HOCl and OCl-, and HOBr and OBr- based on the pH of the treated water. Accurate control of the water's pH is essential for sanitizers to be effective. According to the Michigan Public Swimming Pools Act 368, swimming pool water must be maintained between 7.2 to 8.0. However, a pH range of 7.2 to 7.6 is more practical from a management standpoint.

Chlorine and bromine both are more effective sanitizers when the pH is between 7.2-7.6.

The water's pH also influences the likeliness of scale or water hardness deposits—deposits increase as the pH increases. **Hardness** (water) refers to the quantity of dissolved minerals, chiefly calcium and magnesium that may be deposited as scale. Deposits can be very troublesome in the pool filter, heater, piping and even the pool itself. See chapter 6 for more information on water hardness.

Swimmer irritation increases as the pH gets above 8.0.

If the pH becomes too low, the water becomes aggressive and even corrosive. Irritation to swimmers' eyes, mucous membranes, and skin may result regardless if little or no chlorine or bromine residuals are in the water. Low water pH is the most common cause of swimmer irritation problems.

Maintaining the appropriate pH level is a key part of keeping the pool water balanced and stable.

Table 3.1 Effect of pH on Hypochlorous and Hypobromous acid concentrations.

pH H+ Hydrogen Ion	**HOCI Hypochlorous acid (killing agent) Active**	**OCI- Hypochlorite Ion Inactive**	**HOBr Hypobromous acid (killing agent) Active**	**OBr- Hypobromite Ion Less active**
pH	% Chlorie as HOCI	% Chlorine as OCI-	% Bromine as HOBr	% Bromine as OBr-
6.5	90	10	99.4	0.6
7.0	73	27	98	2
7.5	56	44	94	6
8.0	21	79	83	17
8.5	10	90	57	43

Recommended pH levels:

Maintain the pH of the pool water between 7.2 to 7.6. It is preferable not to exceed 7.6 since the pH of swimmers' eyes is 7.5. Also, as stated above, the effectiveness of the disinfectant in the pool changes with pH levels. The following chart states the disinfectant residual that must be maintained at various pH levels to maintain adequate cleanliness of the water.

Disinfectant	Type of Residual	pH 7.2-7.6	pH 7.6-7.8
Bromine	Bromine	1.0 ppm	2.0 ppm
Chlorine	Free Chlorine	0.4 ppm	1.0 ppm
Chlorinated cyanurate	Free chlorine	1.0 ppm	1.5 ppm

Maintaining pH Levels

When a swimming pool is filled, test the pH of the water. Usually, the incoming water is suitable for swimming pool use with little or no adjustment. Expect changes in the pH with daily use of the pool. The addition of "make-up" water, swimmer's wastes, and acidic pool chemicals all effect the pH of the water.

The addition of pool chemicals is necessary to "balance" the water and get the pH back to the desired level. Daily addition of enough fresh water to raise the pool water level three or four inches, is an effective, convenient, inexpensive way of maintaining the optimum pH range for many swimming pools.

If adding make-up water is ineffective at regaining the desired pH, a chemical must be added to the water for pH management.

There are two methods for controlling pH in pool water.

1. *Manually* — the pool operator applies the proper pH adjusting chemical (this does not include chlorine) into the pool while wearing all the appropriate PPE.
2. *Automatically*— using an automatic pH controlling device operated in conjunction with other pool equipment.

In smaller pools (less than 50,000 gallons), to *decrease* pH it is recommended that sodium bisulfate is used since it is less toxic than other products. Use muriatic acid to decrease pH in larger pools where automatic systems are available to feed it into the pool water. Muriatic acid is a caustic chemical, wear extra personnel protective equipment including goggles when handling it. It is very important not to splash muriatic acid onto your skin or clothing, or into your eyes.

The amount of chemical needed to lower pH is determined with an "acid demand" test kit. To properly test the waterier, a measured amount of pool water is colored with phenol red from the pH test kit. Then a reagent (acid) is added until the color changes to match the color of the desired pH level as shown by the kit. The amount of reagent used in this test is compared with a chart. Knowing the pool volume and using chart information, the amount of chemical needed for lowering pH is determined.

Sodium bisulfate ($NaHSO_4$) can be used for pH and alkalinity reduction in small pools. It is a white, odorless, crystalline material known as a **"pH reducer."** Liquid solutions of sodium bisulfate are highly acidic. Handle with care and wear appropriate personal protective equipment. Use it only after the pool is closed for the day, since it destroys chlorine residuals which will need to be adjusted before bathers return.

Use an acid demand test kit to determine the amount of sodium bisulfate or muriatic acid to apply to the pool water to lower the pH. If the chart with your kit shows only the amounts of muriatic acid to use, 1¼ lbs. (20 ounces) of sodium bisulfate can be used for each pint of muriatic acid recommended. For example, if 2 pints of muriatic acid are recommended, apply 2½ pounds of sodium bisulfate to create the equivalent pH change. If an acid demand test kit is not available, use about one pound of sodium bisulfate per 10,000 gallons of water to lower pH.

GUIDE TO LOWERING pH WITH SODIUM BISULFATE:

Current pH level	Amount of Sodium Bisulfate oz./1,000 gal. pool volume to lower to a desired pH of:		
	7.0	7.5	8.0
8.0	1.4	0.4	
8.5	1.6	0.8	0.3
9.0	2.3	1.3	0.9
9.5	4.0	3.1	2.6
10.0	6.9	5.9	5.5

Example: To determine the ounces of **sodium bisulfate** needed to *lower* the pH of a 24,000 gallon swimming pool from pH 9.0 to 7.5:

$$1.3 \text{ ounces} \times 24 = 31.2 \text{ ounces}$$

Note: Adding 20 ounces of sodium bisulfate has the equivalent effect as adding 16 ounces (1 pint) of muriatic acid.

While wearing PPE, apply sodium bisulfate (to lower pH) with a scoop by scattering or broadcasting the predetermined amount directly onto the pool water surface in the deeper area. The pH may drop quickly due to the formation of carbon dioxide but then rise again as the carbon dioxide escapes into the air. For this reason, recirculate the water while testing to determine the effectiveness of the treatment and if there is a need to repeat the chemical addition.

Liquid acids, including muriatic acid (commercial hydrochloric acid), are not recommended (unless used in automatic feed systems) for pH adjustment because of the safety hazards inherent with handling. If you do use muriatic acid, impermeable gloves and safety glasses must be worn to keep the acid away from the skin and eyes. Eye injuries and acid burns have resulted from failure to observe these precautions. Liquid acid applications should not exceed one quart per 10,000 gallons of water in any one treatment. If automatic feed systems are not available, dispense the liquid close to the water's surface to prevent splashing and apply it to the deepest area of the pool. Keep swimmers out of the water for several hours after each application.

Guide to Raising pH:

One pound (16 ounces) of **sodium carbonate** (soda ash) per 10,000 gallons will raise the pH 0.3.

One pound (16 ounces) of **sodium bicarbonate** (baking soda) per 10,000 gallons will raise the pH 0.10.

Example: To determine the amount of **sodium carbonate** (soda ash) needed to *increase* pH from 7.0 to 7.5 in a 24,000 gallon swimming pool.

$$\frac{24{,}000 \text{ gallons}}{10{,}000 \text{ gallons}} = 2.4;\ 7.5 - 7.0 = 0.5;\ \frac{.5}{.3} = 1.67$$

$$1.67 \times 2.4 \times 16 \text{ ounces} = 64.13 \text{ ounces or } 4 \text{ lbs. soda ash}$$

Example: To determine the amount of **sodium bicarbonate** needed to *increase* the pH from 7.0 to 7.5 in a 24,000 gal. swimming pool:

$$\frac{24{,}000 \text{ gallons}}{10{,}000 \text{ gallons}} = 2.4;\quad 7.5 - 7.0 = .5;\ \frac{.5}{.3} = 5$$

$$5 \times 2.4 \times 16 \text{ ounces} = 192 \text{ ounces sodium bicarbonate}$$

$$192 \text{ ounces} = 12 \text{ pounds of sodium bicarbonate}$$

A single application of sodium bicarbonate should not exceed (2) two pounds per 10,000 gallons. Test the pH 30 to 60 minutes after application.

CHAPTER 3

Review Questions

Pool Disinfectants and pH

Write the answers to the following questions, then check your answers with those in the back of the manual.

1. Match the terms sanitization, oxidation, stabilizer, flocculent, and sequestering agent with the appropriate definition.

___ Sanitization	A. A chemical that, when added to pool water, keeps dissolved metals and minerals in clear solution (suspended).
___ Oxidation	B. Cyanuric acid, also known as conditioner, that slows sunlight from dissi pating chlorine strength.
___ Stabilizer	C. A compound usually used with sand-type filters to form a thin layer of gelatinous substance on the top of the sand, helps trap fine suspended particles that might pass through the sand.
___ Flocculent	D. The chemical process that destroys organic contami nants in pool water not removed by filtration.
___ Sequestering agent	E. The action of the chemical hypochlorous acid (HOCl) that destroys harmful organisms in the pool water.

2. List 5 minimum safety requirements for chlorine gas use.

3. Why is stabilized chlorine (isocyanurate) more effective in an outdoor pool setting than other types of chlorine?

4. When using bromine as a disinfectant, will the pH of the pool water become higher or lower after treatment? Explain why and what you would do to counteract that effect.

5. Name the two methods of producing ozone.

6. Define pH. How is it measured?

7. What are the effects of low pH pool water? High pH?

8. When using acids to control pH, what precautionary measures should be followed?

9. What does a test result of 100 ppm for cyanuric acid indicate? What is the corrective action, if any?

CHAPTER 4

POOL WATER TESTING

LEARNING OBJECTIVES

After completely studying this chapter, you should be able to:

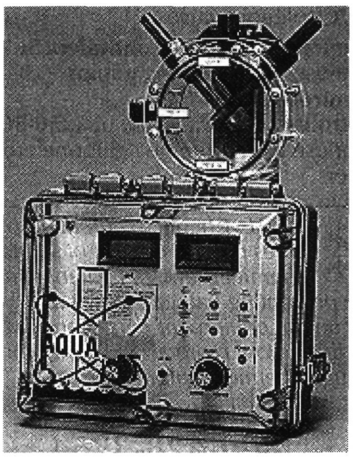
- Compare different pool water testing methods for chlorine.
- Explain the procedures for collecting water samples used in testing.
- Explain the method for colormetrically testing the pH of water.
- Explain what elements constitute water hardness.
- Explain characteristics of low and high water hardness levels.
- Interpret the results of various testing procedures.

There are several brands of water testing kits available.

Regular and exact testing of swimming pools and spa pools is essential to maintain a healthy, clean pool environment. Proper control of all the variables involved in pool chemistry is assured only by constantly monitoring the water, evaluating the findings, adding chemicals, and maintaining automatic chemical feeders as necessary to control proper water balance. While water testing is now easier due to the development of commercial test kits, the quality of the test kits varies considerably. A number of companies produce laboratory-quality kits for more exact chemical readings, but the general-use kits are inexpensive and can be used for spot tests by trained pool personnel. Laboratory-quality kits should be cared for, secured, and used only by a trained operator.

Electronic controllers that read, evaluate, and mechanically adjust the pool water chemistry have simplified the testing and maintenance procedures associated with water chemistry balancing. The applicator need only conduct periodic checks (confidence checks) and simple maintenance procedures to insure that the electronic readout agrees with the water tests. The mechanical controller does everything else, including turning on pumps and adding the proper chemicals to balance the water chemistry.

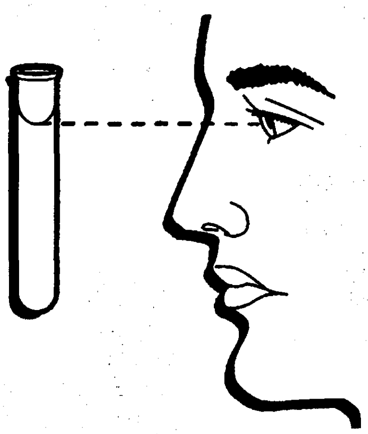
Regardless of the system used, all applicators must follow basic rules when testing water. Disinterest, sloppy instrument handling, hurried procedures, bad reagents, poor choice of sampling location, or inaccurate measurements will lead to problems.



Automated controllers can sense and automatically treat for both chlorine residual and pH balance.

The following rules apply to all chemical testing:

1. The state of Michigan requires that pool water be tested at least three times a day with the results recorded on a daily operational sheet (see appendix F). Test at times when the pool is used to capacity or during normal peak periods of use.
2. Make certain that the sample is representative of the pool water. Select a sample location that contains well-mixed pool water. Obtain your sample from at least 12" below the water's surface. Do not collect the sample from an area adjacent to an inlet.
3. Follow test kit instructions—water testing is a precise process that demands accuracy in measuring amounts of reagents involved and in observing time and temperature requirements.
4. Add the water sample to the tube until the bottom of the curved-upper surface (called the meniscus) is even with the prescribed level. The outer edges will be higher than the center causing a curvature in the water surface. This curvature is called a meniscus.



Fill the sample tube with pool water so that the low point of the meniscus rests at the fill mark. Have the fill line at eye level when filling the sample container.

5. Rinse all solution tubes, stirring rods, and equipment thoroughly after each use, both inside and outside. Do not rinse droppers or reagent bottles, or let the droppers touch pool water. Rinse the droppers only with a small amount of the reagent with which they are associated. Do not handle the equipment or reagents with dirty hands, and, never cover the sample tube with a thumb or a finger. Rinse off any reagents that get on the skin.
6. Properly box or case the equipment, and store in a cool, clean, dry place. Do not interchange parts such as solution tubes, bottle caps, or droppers.

Reckless or inexact methods of water testing leads to inaccurate results and possibly an unsafe condition for people using the facility. Water must be kept in a healthy, clean and clear condition at all times.

Testing for Chlorine

There are three types of chlorine test readings: free, combined, and total. Free chlorine plus combined chlorine equals total chlorine. Only the **free chlorine** is effective in killing bacteria or algae. The **combined chlorine** is bound with other elements (contaminants) and needs further chlorine additions to release it. The **total chlorine**, as measured by the OTO test (below) is the sum of the free and combined chlorine.

DPD Testing

Simplified water testing for the pool operator is now possible with new and better testing equipment. The quality and type of test kits vary. The MDEQ *only* approves results obtained by using the DPD (Diethyl-p-Phenylenediamine) type of test kits.

DPD testing kits are manufactured with either liquid or tablet reagents. DPD tablets or liquid is used to test for **free available chlorine (F.A.C.), combined available chlorine (C.A.C.)** commonly called **chloramines**, and **total available chlorine (T.A.C.)**. Both tablet and liquid forms give the user the same necessary information when directions are closely followed.

(F.A.C.) + (C.A.C.) = T.A.C.

Orthotolidine Testing (OTO)

Orthotolidine testing (OTO) reveals only the amount of total chlorine found in the pool water and does not distinguish between free available and combined chlorine levels. Therefore, it is not recognized by Health professionals as an adequate pool water testing procedure.

Typical Chlorine Testing Procedures

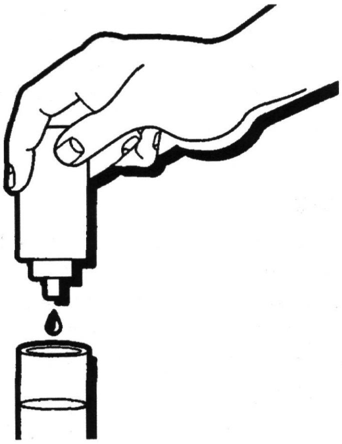
Before initiating any water tests, read the specific kit directions and be familiar with procedures. Before and after each test, the cells of the test kit (viewing tubes) must be cleaned to insure exact test results. The pool operator should rinse the vial with pool water and:

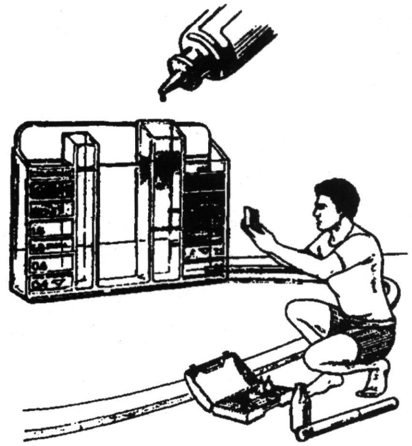
a. Take the sample from the pool 12 inches below the water's surface away from water inlets.
b. Add reagent #1 tablet, or liquid reagent #1 and #2 to the proper viewing tube containing the pool water to measure free available chlorine residual.
c. Add reagent #3 tablet if testing for combined or total chlorine in same tube, or add liquid #3 to #1 and #2.
d. Combined chlorine, or chloramines, is determined by subtracting the FAC reading from the TAC.

When conducting the pool water test, remember:

- Follow the kit directions for each test to be performed.
- Never place the thumb or finger over the cell (tube) opening, use the caps provided to prevent contamination.
- Briefly shake or gently stir the sample to dissolve the reagent.

- Read the colored viewing tube under natural or incandescent lighting (not fluorescent).
- Rinse the viewing tubes with pool water or tap water when the test is completed.





Testing pool water for pH, chlorine residual, total alkalinity, and calcium hardness is an important part of pool maintenance. Chemical reagents are added to a water sample that gives an indication of the water's condition.

Liquid reagents have a one-year shelf life. Tablets have a two-year life under normal, dry storage conditions. Placing or storing either the liquid or tablet reagents in a hot, moist environment, leaving them in the sun, or allowing the liquid to freeze, shortens the life span. The accuracy of the test is likely to decrease if reagents are stored inaccurately or for long periods of time.

If the tablets are off-colored (brown instead of white), crushed, or appear to have been contaminated, discard them. Do not touch the dispensing tops of liquid reagents because body oils on the hands can contaminate the reagent.

Other reagent tablets besides #1 and #3 are available. Number two (#2) is used to test for monochloramines, and number four (#4) measures total chlorine only.

If you conduct a DPD test for chlorine levels and no color shows after adding the reagent, or the color remains only for a short period then disappears (becomes clear), this may indicate that there is too much chlorine in the pool. The loss of color from the reagent indicates "bleaching out" of the test water sample. To double-check your results, discard the sample and take another. Before adding the reagent, dilute this sample with a known amount of tap or distilled water. Multiply the result by the appropriate factor: for a 1:1 dilution multiply the result by two; for a 1:3 dilution multiply by 4, etc.

If the DPD test indicates no difference between free and total available chlorine, but swimmers complain of red, irritated eyes and strong odors, the water could have a chloramine (combined chlorine) problem. If testing fails to find a problem, there could be a residual of #3 reagent left in the viewing tube that is causing the false reading. Rinse, clean the tube, and repeat the test.

Testing pH

The pH of water is usually tested by matching reagent colors against a colormetric standard. The reagent generally used for swimming pool water is phenol red, which has a pH range of 6.8 to 8.4 and a corresponding color range of yellow to red. Other reagents that are occasionally used for water pH analysis include bromthymol blue, with a pH sensitivity range of 6.0 to 7.6 and a color range of yellow to blue; and cresol red, with a pH sensitivity range of 7.2 to 8.8 and a color range of yellow to red.

Knowing the pH of pool water is essential for properly controlling all the water chemistry parameters. Test pH at least daily, or 3 times a day when the disinfectant residual is checked. Confirm that the pH is within the desired 7.2-7.6 range. Take water samples from the pool for testing the pH, not from a pipe tap or in the equipment room.

The pH can be measured either colormetrically or with an electric metering device. The colormetric method is the preferred method of analysis. Sodium thiosulfate is added to the sample to neutralize any chlorine-based residual, then a colored indicator solution—phenol red—is added. Use **ONLY** the reagent supplied by the manufacturer for testing purposes since the standards are calibrated for use with a specific test kit and may give inaccurate readings if used with another kit from a different company.

To Colormetrically Test the pH of the Water

1. Fill the viewing tube or cell of the test kit with pool water to the correct level marked on the tube. Some test kits require that a "comparator tube" also be filled for analysis.
2. Using the dropper provided, add sodium thiosulfate (chlorine neutralizer) into the sample to remove any residual chlorine. It is recommended to add one drop for every part per million of disinfectant level in the pool. For example, if the free available chlorine residual is 3.0 ppm, use 3 drops of sodium thiosulfate to neutralize the solution. Neutralizing the chlorine prevents the disinfectant from interfering with the phenol red indicator reaction. This is especially important when the disinfectant is bromine or the chlorine residual is excessively high.

3. Add a measured amount of the indicator solution to the sample. Usually 5 drops of indicator is used. Mix this solution by swirling the tube of sample water with the top or stopper on the cell. Do not contaminate the sample by placing your finger over the cell.
4. Compare the color of the sample test water to the standard on the test kit. Do not attempt to interpolate closer than midway between two standards or interpolate to a number of the scale. According to the Michigan Public Swimming Pools Act 368, swimming pool water must be maintained between 7.2 to 8.0. However, a pH range of 7.2 to 7.6 is more practical from a management standpoint.

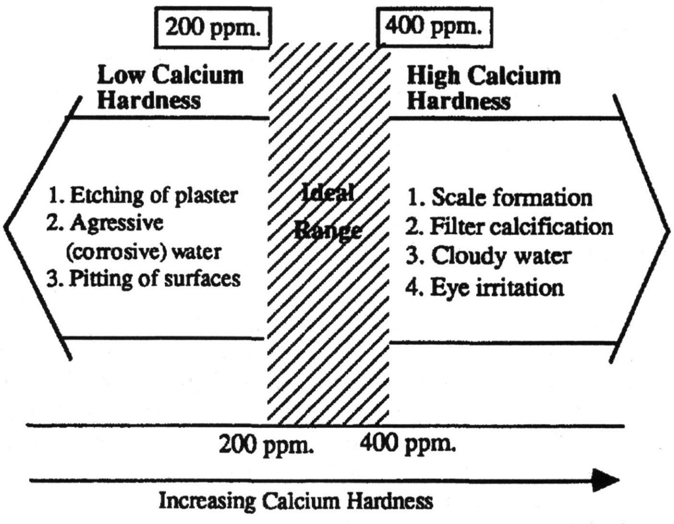
Testing for Calcium Hardness Levels

Total hardness is the measure of calcium (Ca) and magnesium (Mg) in the water. Excessive hardness—the combination of calcium [Ca] and magnesium [Mg]—causes calcium scale to build up on the walls and floor of plaster finished pools and spas. It also leaves scale build-up in heaters, heat exchangers, and other filtration components. Recognize that it is not the magnesium that forms the scale, only the calcium forms scale. Therefore in the pool industry, the focus is on maintenance of calcium levels.

Generally, low calcium hardness presents a larger problem to pools than high calcium hardness does. When the hardness level drops too low, the water becomes aggressive and will cause corrosion, pitting of plaster, and grout to dissolve. If pH, calcium hardness and total alkalinity are low, the corrosiveness and aggressiveness of the pool water will be greatly increased.

Control of scaling or aggressive water requires the calcium hardness level to be kept above 200 ppm and *below* 400 ppm. The suggested range is 200-300 ppm. Use the **Langelier saturation index** (see chapter 6) calculation to determine if the pool water is either aggressive (low hardness level) or scale forming (high hardness level).

Pharmaceutical grade calcium chloride (CaCl) is used to increase the hardness level. Because calcium chloride produces a significant amount of heat, the total amount needed should be divided into half and applied to the pool in two separate but equal doses. Remember when dissolving chemicals, add chemicals to water; never add water to chemicals.



To *reduce* the calcium levels, dilution is recommended. Remove some of the pool water and replace it with fresh. Trucked-in water from an alternate source may be the answer to control hardness. Calcium can make up as much as 75% of the total hardness with the remainder being primarily magnesium.

To test for hardness, a water sample is taken from at least 12 inches below the surface of the water. This volume of sample water is treated with a calcium buffer and then a dye. A reagent is then added to the sample one drop at a time and mixed. The number of drops it takes to produce a complete color change, from red to blue, is then multiplied by a *constant* provided by the test kit manufacturer. This gives the pool operator the ppm concentration of calcium. In conducting hardness tests, proceed slowly and allow enough time to mix the sample after each drop is added.

Testing for hardness may have special problems. It is possible that the color change will never take place. This indicates the presence of interference, probably copper. To remedy this, add a few drops of hardness reagent before adding the buffer and indicator. The number of drops added should be included in the total number of hardness reagent drops to obtain the complete color change.

Testing for Total Alkalinity (Measuring Calcium Carbonate)

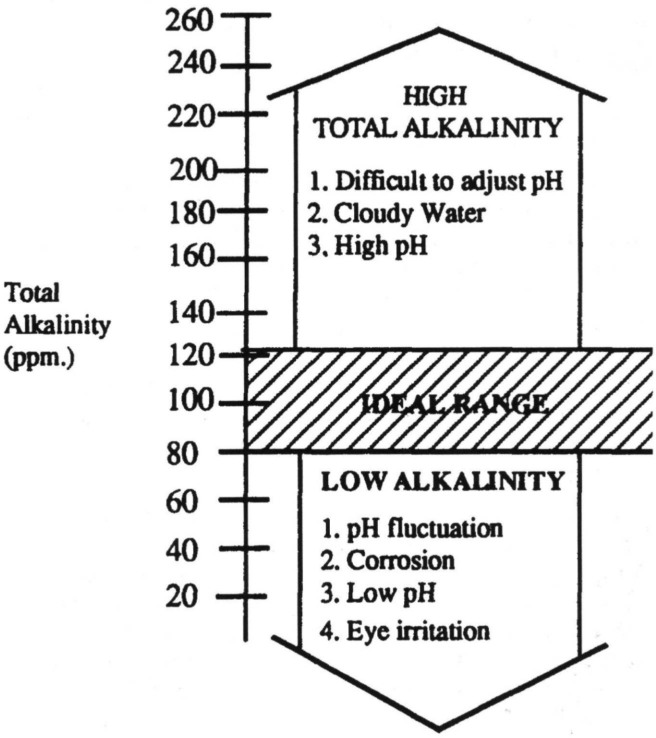
Alkalinity in water represents the amount of bi-carbonates, carbonates, hydroxide and sometimes borates, silicates and phosphates. Total alkalinity is the resistance of water to changes in pH. The higher the total alkalinity, the more difficult it is to change the pH with soda ash or acid.

Testing for total alkalinity is essential to make proper determinations of the saturation index (see chapter 6) as well as for bather comfort and ease of pH control. Total alkalinity (calcium carbonate) should be kept between 80-120 ppm for pools with inert liners, and between 100 to 125 ppm for pools with plaster finished surfaces.

The pool water total alkalinity is measured using a test kit. Although test kits vary, the procedure is basically the same. A quantity of water is placed in the viewing cell and alkalinity indicator is added. This indicator produces either a blue or green color when calcium carbonate (alkalinity) is present. A reagent is then added to this mixture using a dropper or measuring device. The operator must count the number of drops necessary to change the color of the test sample from blue or green to a reddish, amber color. The color change represents the neutralizing of the alkalinity.

Determine alkalinity by multiplying the number of drops from the dropper by 10. Each drop represents 10 ppm per drop. For example 10 ppm x 11 drops would equal a total alkalinity of 110 ppm.

Testing for total alkalinity has special problems. When using a reagent which is older than its one-year shelf life, the test indicator may give different or opposite color readings. Therefore, replace the reagent annually and discard the old reagents.



It is recommended that the results of total alkalinity be considered before adjusting pH. It is essential to maintain a total alkalinity of 80-120 ppm in swimming pools to maintain a stable pH. The direction of pH change, or even the need for adding chemicals is greatly influenced by the level of total alkalinity. Total alkalinity does not vary quickly.

Total Dissolved Solids (TDS)

Total dissolved solids (TDS) is the measurement of all materials dissolved in the water, i.e. calcium, dissolved organic and inorganic materials, carbonates, salts from chlorine residue, swimmer waste, soluble hair and body lotion, or anything placed in the pool that can be dissolved. The total dissolved solids (TDS) in a pool should not exceed 1,500 ppm. High TDS is common with spa water with high bather load, high chemical needs and a relatively small volume of water. TDS can only be corrected by dilution with water with low TDS or completely draining and refilling with fresh water. Determining the TDS level requires a special meter or test kit. Testing meters normally have a scale with a range of 0-5,000 ppm. TDS kits are priced according to quality and accuracy.

Cyanuric Acid Testing

Cyanuric acid is commonly added to outdoor pools as a chlorine stabilizer or chlorine conditioner. The concentration of cyanuric acid must be monitored carefully to insure that the chlorine does not become over stabilized. Cyanuric acid products are not recommended for indoor pools and spas, since the need for chlorine protection from the sun is not a concern.

The acceptable range of cyanuric acid is generally between 30-80 ppm. Cyanuric acid levels above 100 ppm are prohibited by the MDEQ.

Most cyanuric acid tests are conducted by mixing stabilized melamine solutions and pool water, which results in a cloudy solution. A stir or dip rod, with a black dot on the rod, is placed in the viewing test cell. The rod is lowered into the solution. A graduated scale is used to measure when the black dot disappears from view. Other test methods include tablets or more concentrated reagents. All tests are based on turbidity (cloudiness) of the solution. Melamine tests are not very accurate below 15 ppm or above 70 ppm.

Copper Testing

Test kits are available to detect copper in pool water. Most copper test kits produce a blue or green color when copper is present in the pool water. The copper level (ppm) is measured by the color standard included with the test kit.

Copper found in pool water contributes to staining of pool walls, water discoloration, and turns hair or nail cuticles of the pool users green or blue. Therefore, the recommended copper level is 0 ppm. If copper is present, maintaining a pH of 7.2 to 7.3 and a hardness of 350 ppm reduces the negative influences of copper.

Iron Testing

Test kits are available for testing iron concentration levels. Reagents produce brown to red colors in the presence of iron. The reddish brown color is then measured with a color standard found in the test kit.

Dissolved iron is responsible for staining and color problems in pool water and on pool surfaces. The addition of chlorine in an adequate concentration helps to precipitate out the iron and allows the filter to remove it.

Test Strips for Water Chemistry Levels

Test strips are available to determine chlorine and pH values as well as all other parameters of water chemistry. These test strips are easy to use but they are only useful as general guidelines. Do not rely upon test strips for accurate water chemistry readings.

Record Keeping

When performing your water tests, keep a written record of the results. This information is helpful for understanding the dynamics of your pool's system. Over time, you may notice trends and be able to anticipate water needs and keep a tighter control on your water quality. This information is also useful for making purchasing decisions. The MDEQ requires that certain information be maintained (see appendix F).

Summary of Water Chemistry Parameter Testing

To insure proper water quality and sanitizing levels of any swimming pool or spa pool, the operator must have a working knowledge of all parameters effecting water chemistry and must be familiar with water testing equipment. Testing equipment must be maintained in clean conditions, and fresh reagents used for achieving accurate results. Operators must record the results of their testing activities.

CHAPTER 4 Review Questions

Pool Water Testing

Write the answers to the following questions, then check your answers with those in the back of the manual.

1. What is the frequency recommended by the Michigan Department of Environmental Quality for pool water testing?
   a. Once a day.
   b. Twice a day.
   c. Three times a day.
   d. Every other day.

2. Why is the OTO test not approved for use in Michigan by environmental health professionals?

3. Explain the typical testing procedures for chlorine in pool water.

4. Name two ways the pool water sample can become contaminated during collection and testing.

5. During a DPD test, what does the "loss of color" indicate after the reagent is added to the sample? What can be done to solve the problem?

6. If you test the pool water and find that the free available chlorine measured 1.5 ppm, the total available chlorine was 2.5 ppm, what would the combined chlorine (chloramines) be?
   a. 2.5 ppm
   b. 2.0 ppm
   c. 1.5 ppm
   d. 1.0 ppm
   e. 4.0 ppm

7. What could cause inaccurate test results when testing for the pH of the water?
   a. Touching and contaminating the reagents.
   b. Not adding enough chlorine neutralizer to the sample before adding phenol red.
   c. Using old reagents.
   d. All of the above.

8. In testing for total alkalinity, the number of reagent drops added to the sample are counted and multiplied by 10 and the result is measured as ppm. What does the sample result of 21 drops indicate?

9. Are test paper strips MDEQ approved for routine testing of the pool water?

CHAPTER 5

BACTERIOLOGICAL ANALYSIS OF POOL WATER

LEARNING OBJECTIVES

After completely studying this chapter, you should be able to:

- Explain why the coliform group of bacteria and the standard plate count are used as contaminant indicators.
- Collect a water sample for bacterial analysis.
- Know when to take a sample for bacteriological analysis and understand the importance of sample timing
- Explain laboratory testing of water.
- Interpret sample results.
- Explain the importance of routine sampling and record keeping.

Purpose

Bacteriological analysis of swimming pool water determines the sanitary quality and suitability for public use. Pool water can become highly contaminated or polluted, at least momentarily, from the swimmers in it. Waste material from one swimmer can be taken into the mouth, nose, or throat of another swimmer before the microorganisms are destroyed by the pool water's disinfectant if the amount or concentration of the disinfectant is inadequate.

Identifying pathogenic organisms in the water is extremely difficult, unreliable, and not routinely undertaken as a laboratory procedure. Instead, the presence of other microorganisms (indicators), which may be associated with pathogenic organisms, is determined. For example, presence of *E. coli,* a common intestinal bacteria, indicates presence of fecal contamination and the possibility of contamination by pathogenic microorganisms. Because the density of *indicator organisms* is much greater than the density of pathogenic organisms, indicator organisms are used to measure the degree of contamination. The laboratory tests that measure contamination require incubation of specimens for a period from 18 to 96 hours, depending on various factors.

Standards

The current standards for judging the bacteriological quality of the swimming pool water are based on the **"coliform group"** and the **"standard plate count."** In Michigan public swimming pools, the presence of organisms of the coliform group and/or a standard plate count of more than 200 bacteria per milliliter of sample, either in two consecutive samples, or in more than 10% of the samples in a series, is considered unacceptable water quality.

The coliform group of bacteria has been used for many years to indicate sewage pollution of water and to evaluate the quality of drinking water. It serves these purposes well, but its applicability to swimming pools is limited. Testing for the coliform group indicates intestinal bacteria but does not reflect the possible contaminants responsible for infections and diseases of the eyes, ears, nose, and throat. Because coliform bacteria are readily destroyed by chlorine, they are not a good indicator of more chlorine-resistant organisms, such as certain viruses.

The standard plate count, also referred to as the "bacteria count," "total viable bacterial count," or "agar plate count," is not commonly used as a standard for potable water. It supplements the coliform test and may help in its interpretation. It is useful in judging the efficiency of water treatment and in that respect is particularly useful for indoor swimming pools. It is less appropriate for outdoor pools where dust, leaves and similar materials can influence the total number of bacteria in the pool.

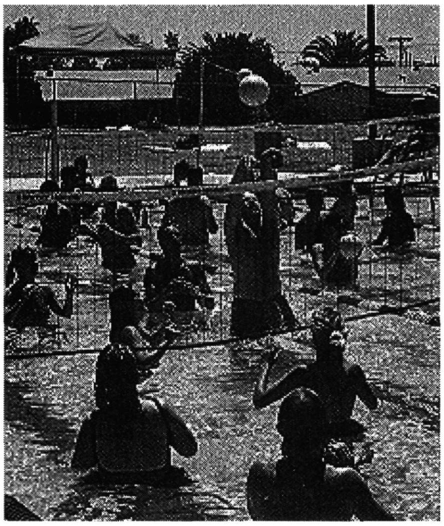
Epidemiological evidence about the role of swimming pool water in the transmission of diseases confirms the concern for maintaining water quality. The bacteriological standards for swimming pools are intended to assure bather health and safety. These standards can be achieved through reasonable care.

Interest is growing in other organisms as indicators of pollution, such as "cocci," which are nose and throat bacteria. The Sixteenth Edition of *Standard Methods* (1985) has test procedures for fecal coliforms and fecal streptococci. This text also has tentative procedures for measuring *Staphylococcus aureus* and *Pseudomonas aeruginosa* in bathing waters. However, more adequate information will be needed before acceptable limits or standards for these organisms can be set.

Frequency and Timing of Sampling

Michigan's rules for public pools requires the collection and bacteriological analysis of samples once a week, or more often if directed by the state or local health officer or department. There also can be a reduction in sampling frequency if certain sanitary procedures and criteria are being followed closely and an acceptable history of bacteriological sampling is demonstrated over a specified time. The number of inspections by the local or state health department also is a factor in reduction of sampling frequency.

The frequency of sampling should increase when there is heavy bather use of the pool. If possible, collect samples only when swimmers are in the pool, preferably during periods of peak use. Because the maximum amount of contamination exists within approximately the first five minutes after the swimmers have entered the water, collect the samples within this period. If the water quality under such extreme conditions is satisfactory, it is reasonable to assume that the water quality is satisfactory at other times when the bather use is less. Vary the hour of the day, or day of the week for collecting samples to obtain more representative sampling of the pool water quality. However, samples collected when no one is in the pool do not necessarily reflect the water quality when swimmers are in the water. There can be a sense of false security by just relying upon a sample taken when no one is in the pool.



Collect samples for bacteriological analysis when swimmers are in the pool, preferably during periods of peak use.

Test for the free available chlorine or other disinfectant at every inspection, whether bathers are present or not. A lower than acceptable chemical residual (free available chlorine) indicates potential trouble with pool operations.

Sampling Points. Take samples from the pool itself, not from a point in the piping or recirculation system. Collect the sample under the water surface (usually 12-18 inches) and away from the water inlets through which the newly introduced disinfectant flows into the pool. Sample as close as possible to a group of swimmers.

Collection Procedures

Sample Bottles. Collect all swimming pool water samples in clean, specially treated, sterile bottles containing sodium thiosulfate—a chlorine neutralizer. Prepare the bottles in accordance with the text of *Standard Methods* or use bottles provided by a certified lab. The sodium thiosulfate neutralizes the chlorine residual before the testing for organisms can begin. This neutralization of the chlorine must begin as soon as possible so that the chlorine does not kill the bacteria while the sample is on the way to the laboratory.

Hold the bottom of the bottle and remove the cap. Be careful to protect the sterile cap and the bottle neck from contamination. Plunge the bottle, neck downward, 12"-18" inches below the water surface. Fill the bottle at that depth with a sweeping forward motion, bringing the bottle up toward the water's surface. Keep the bottle away from your other hand and body parts. Discard some water so that the bottle is filled to the neck of the bottle. Carefully put the cap back on the bottle. Do not rinse the bottle—rinsing removes the sodium thiosulfate. Avoid contamination from floating debris.

Related Data

Determine the chlorine or bromine residual and the pH of the water at the sampling point. Also, record the number of swimmers in the pool. For proper identification, write on the sample reporting form this pertinent information, along with the pool name, date of the sample, sampling point description, time the sample was collected, and the sample number.

Transportation and Storage

Immediately after collecting water samples, deliver them to a certified lab. Start the bacteriological examination of water samples within 1-48 hours to minimize the biological changes that occur between the times of collection and actual testing procedures. After 48 hours, the accuracy and validity of the sample cannot be guaranteed by the laboratory and a false-negative result could be obtained from the sample. If the laboratory analysis cannot be started within one hour after the sample is collected, store the sample on ice, or in cold storage, according to Standard Methods.

Interpretation of Sample Data

Bacteriologic data from swimming pool water can be useful in judging the pool's suitability for use, but the data alone will not give an exact answer to whether a specific pool is "safe" or "unsafe." The test results must be interpreted with additional information such as the conditions of the pool at the time of sampling: i.e. water clarity, disinfection levels, pH, chemical equilibrium, and bather loading. The sampling procedures, the age of the sample at the time of analysis, and the limitations of the test procedures also must be considered.

It is important to establish a pool's bacteriologic profile based on a continued, routine sampling. Depending upon isolated "grab" samples for feed back is not acceptable since the laboratory analysis of a sample may take up to 96 hours. With such a waiting period, the results cannot dictate a change in pool operating procedures on the same day the sample was collected because pool water conditions will have changed by the time laboratory results are known. However, the results can point to changes that must occur in the pool operating procedures to help protect public health.

CHAPTER 5

Review Questions

Bacteriological Analysis of Pool Water

Write the answers to the following questions, then check your answers with those in the back of the manual.

1. What are the problems associated with identifying pathogenic organisms in pool water?
   a. Extremely difficult
   b. Unreliable
   c. Not routinely done as lab procedure
   d. All of the above.

2. Define "coliform group" and explain why it is important for testing.

3. When should the water be tested for bacteria? Who determines when to sample?

4. What day or time is best to take a pool water sample to test for bacteria?
   a. In the morning before swimmers arrive.
   b. At the end of the day right after swimmers leave.
   c. When swimmers are active in the pool, preferably five minutes after they enter the water.
   d. Mid-afternoon, regardless of swimmers.

5. Explain the collection procedure when taking a water sample for analysis.

6. Name the two types of laboratory testing used for bacteriological water analysis. Which one is recommended?

7. What conditions of the pool environment must also be considered when interpreting bacteriologic data to determine if the pool is safe to use?

8. If the water is sampled for bacteriological analysis, what factors must be considered to determine the validity of the sample?

9. When doing a bacteriological analysis, where is the best location in the pool for pulling a water sample? What would be a poor sampling location?

CHAPTER 6

WATER CHEMISTRY AND POOL WATER BALANCE

LEARNING OBJECTIVES

After completely studying this chapter, you should be able to:

- Understand and list the parameters upon which water balance is based.
- Calculate if the pool water is "balanced," "scale-forming" or "aggressive/corrosive" using the Langelier Saturation Index.
- List problems associated with low pH and high pH pool water.
- Understand the relationship between pH and total alkalinity of the pool water.
- Explain how to lower total alkalinity in pool water.
- List the acceptable water quality ranges for total hardness, total alkalinity and total dissolved solids.
- Explain how over- and under-saturation affects water quality.

The pool operator must pay close attention to water chemistry parameters to control the chemical equilibrium of pool water. The **Langelier Saturation Index** for calculating saturation is used to determine if the pool water is under-saturated or over-saturated. **Under-saturated** water condition is commonly called corrosive or aggressive. When water is in an **over-saturated** condition, it is scale-forming.

It is the nature of water to dissolve the things with which it comes into contact, until it becomes saturated. When this happens, water loses this excess material (that which was dissolved) and the material will precipitate, or come out of solution. This over-saturated condition is called "scale forming."

Langelier Saturation Index

Stable water quality is based on proper use of the saturation index and formula. Bringing the pH, total alkalinity, total hardness, temperature, and total dissolved solids together using the index gives the pool operator the complete answer to pool water quality and balance.

Various factors are used to calculate saturation levels. The results provide the operator information needed to balance the pool and correct its corrosive or scale-forming condition.

First, the pool operator must test all parameters of the water chemistry with the appropriate test kits and then obtain the correct "factors" from Table 1. Next, the numerical values from Table 1 are substituted into the following formula:

SATURATION INDEX = pH + TF + CF + AF − 12.1

pH: measured from test kit (chapter 4)
TF: temperature factor, measured at pool
CF: calcium hardness, measured from test kit (chapter 4)
AF: alkalinity factor, measured at pool (chapter 4)

Water with a calculated index between:
-0.5 and 0.5 is *balanced.*

OVER
0.5 is *scale-forming* (over-saturated).

BELOW
-0.5 is *corrosive* (under-saturated).

Example:

A swimming pool has a F.A.C. of 2.0 ppm, total available chlorine (T.A.C.) residual of 2.5 ppm, with a pH of 7.0. The total alkalinity is 50 ppm and calcium hardness is 200 ppm; water temperature is 84° F. ***Is the pool water scale-forming?***

SATURATION INDEX = (pH) 7.0 + (TF) 0.7 + (CF) 1.9 + (AF) 1.7 − 12.1 = -0.8

In this equation we are given the pH of 7.0.

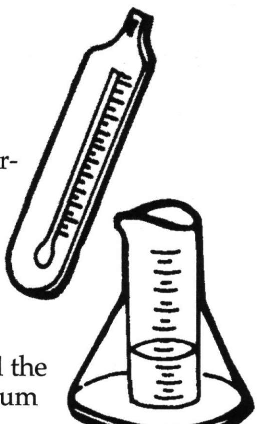
Table 1 shows that when:

- Water temperature is 84° F, the temperature factor (TF) is 0.7.
- Calcium hardness is 200 ppm the CF is 1.9.
- Alkalinity is 50 ppm, the AF is 1.7.

The equation solution equals -0.8. From the saturation index information above, this indicates a corrosive water condition.

Parameters for Saturation Index

Temperature



The higher the temperature of the pool water, the less soluble calcium carbonate becomes. In most cases water temperature cannot be kept constant due to unpredictable weather and environmental conditions. As a pool operator, be aware of this and monitor the temperature when other water parameters are checked. Keep in mind the influence temperature has on the calcium carbonate levels—warmer water, less soluble; colder water, more soluble.

pH

Accurate control of the pH of swimming pool water is essential. According to the Michigan Public Swimming Pools Act 368, swimming pool water must be maintained between 7.2 to 8.0. However, a pH range of 7.2 to 7.6 is more practical from a management standpoint. Simply stated, pH is a numerical value that indicates whether water is acid, basic, or neutral (see Chapter 3). The concentration of hydrogen ions determines the pH of water. The greater the hydrogen concentration the lower the pH. Pure distilled water has a pH of 7.0, which is considered neutral. Water with a pH of less than 7.0 is said to be acidic, and the smaller the number the more acidic the water. On the other hand, water with a pH greater than 7.0 is basic, the larger the number, the more basic the water. Healthy pools require that water is slightly basic. The optimum pH measurement for pool water is 7.2 – 7.6. pH plays two major roles in water chemistry—it buffers acidic disinfectants added to swimming pool water, and it plays the most significant role in the water balancing equation (Langelier Saturation Index).

To *decrease* the pH of pool water, either a granular acid (sodium bisulfate) or liquid acid (muriatic acid) is added. Sodium bisulfate ($NaHSO_4$) is an acid salt that is frequently used because it is relatively easy to handle. The white granular compound can be added by chemical feeder or by dissolving in water and then pouring directly into the pool.

Muriatic acid is the commercial grade of hydrochloric acid (HCl) that is also used for reducing pH of pool water. Muriatic acid is a corrosive acid that is relatively inexpensive, but requires extremely careful handling. Wear rubber gloves and safety glasses when handling

Table 1. Numerical values for saturation index formula.

WATER TEMP (°F)	TEMP. FACTOR TF	PPM $CaCO_3$	CALCIUM HARDNESS CF	TOTAL ALKALINITY AS PPM $CaCO_3$	ALKALINITY FACTOR AF
32	0.0	5	0.3	5	0.7
37	0.1	25	1.0	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
128	1.0	1000	2.6	1000	3.0

muriatic acid. Use caution when storing muriatic acid. If container lids do not fit tightly, fumes from the acid can cause damage to electrical equipment, heating equipment, and metal surfaces.

To *increase* the pool water pH to a more basic condition, adding soda ash (sodium carbonate) is recommended. One pound (16 ounces) of sodium carbonate per 10,000 gallons will raise pH 0.3. Add soda ash to the pool by dissolving the powder in water and feeding the solution through a chemical feeder, or dissolved it in a bucket and pour the solution directly into the pool water. Add soda ash when the pool is closed, preferably in the evening after is has closed for the day. See Chapter 3 for more information on pH management.

Failure to keep the pool water within the pH range of 7.2 – 7.6 can produce the following results:

Low pH (acidic)	**High pH (basic)**
Equipment destruction	Scale forming
Red eyes	Reduced Chlorine effectiveness
Hair loss	Plugged filtration system
Pool surfaces deteriorate	Irritation to users
Staining	Cloudy water
Cloudy water	
Scale removing	

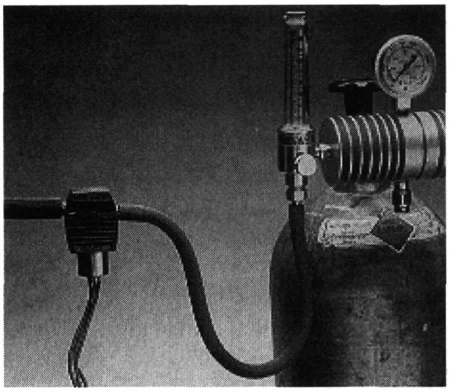
The pH level effects the ability of chlorine to sanitize pool water. The higher the pH, the lower the amount of hypochloric acid available to sanitize and oxidize the unwanted materials in pool water. (See Table 2.) Pool water pH has a similar effect on the effectiveness of bromine. See Chapter 3 for more details.

Table 2. Effect of pH on chlorine activity.

Hypochlorous Acid Chlorine as HOCl (Active) HOCl	pH	Hypochlorite Ion Chlorine as OCl (Inactive) OCl
90%	6.5	10%
73%	7.0	27%
66%	7.2	34%
45%	7.6	55%
21%	8.0	79%
10%	8.5	90%

Lowering pH with Carbon Dioxide (CO_2)

The use of carbon dioxide (CO_2) as an alternative to liquid and dry acids has recently become a popular method for lowering pH of pool water. When CO_2 is dissolved in water it forms a mild acid compound and reduces pH. While lowering pH, CO_2 also raises total alkalinity since it forms a bicarbonate salt. Because CO_2 increases total alkalinity of the water, it should not be used in pools where high alkalinity is a problem, since bicarbonate scale can form.



Calcium Carbonate ($CaCO_3$)

Calcium carbonate ($CaCO_3$) is a mineral present in all water, either naturally occurring in the water or introduced with the addition of chemicals to pool water. Calcium carbonate is the least soluble mineral found in water, and, therefore, it is the one mineral that becomes under-saturated. The degree of saturation by calcium carbonate is governed by pH, temperature, alkalinity, calcium hardness, and total dissolved solids. At higher temperatures, such as in spas or hot tubs, calcium carbonate becomes even less soluble. Controlling calcium carbonate is essential. Test kits are used to measure the ppm calcium carbonate available in the water.

Spas and hot tubs have greater water balancing demands than larger pools because of higher water temperatures and bather loads.

Under-saturated water is aggressive and has corrosive action against equipment, the pool structure, and swimmers' skin. Under-saturation damages pool walls, plumbing, and filtration system equipment. Brown, black, or green water, which contributes to surface stains on the pool walls, floor, and structure, is also characteristic of under-saturated water. This is caused by the under-saturated water attacking the metal components of the filtration system.

A symptom of over-saturation is scale formation—scale forms on the walls of the pool and on the insides of plumbing equipment. This may inhibit equipment performance and lead to equipment failure.

Total Alkalinity and Its Control

Total alkalinity is the measure of the pool's buffering capacity to resist pH change. Without complete control of the total alkalinity portion of the water chemistry, the pH will rise and fall abruptly. The ability to resist this change in pH is due to the presence of carbonate ions. There are other compounds that also provide some buffering.

The pool operator must control both the amount of carbonate alkalinity and the pH to provide enough calcium carbonate to saturate the water without having more than is required. With a desirable pH range of 7.2 – 7.6, most of the carbonate ions are in the bicarbonate form, which provides buffering and a small amount of carbonation.

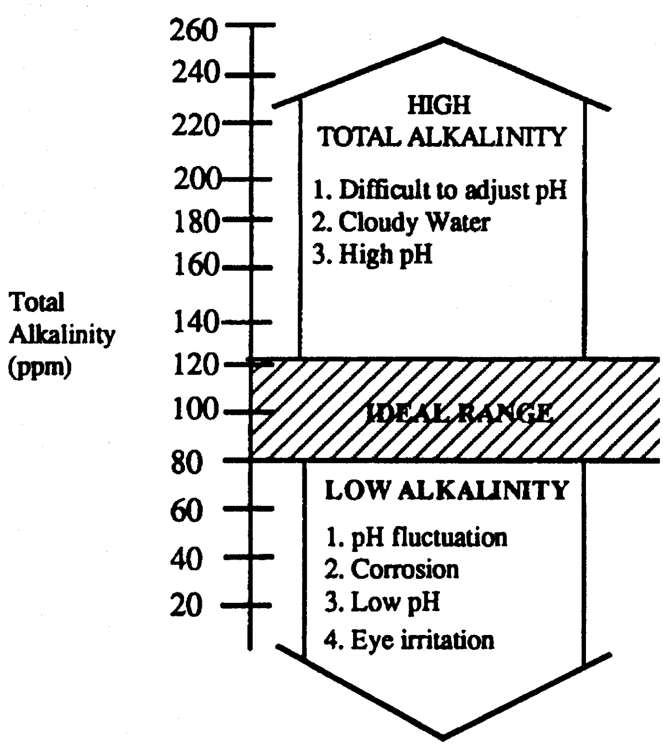
In general, total alkalinity must be kept between 80 ppm and 125 ppm, but pools with liners should be kept at 80-120 ppm, and plaster finished pools should have a total alkalinity of 100 – 125 ppm.

There are consequences when alkalinity is either too high or too low. Water with a low total alkalinity acts much like water with a low pH (aggressive), and water with a high total alkalinity acts much like a water with high pH (basic, scale-forming).

A low total alkalinity makes it difficult to maintain a desired pH, and can lead to corrosive water which causes damage to equipment. Green water is another symptom of low total alkalinity. To raise total alkalinity in pool water, add sodium bicarbonate. If the total alkalinity is less than 80 ppm, it can be raised approximately 10 ppm per 10,000 gallons of pool water by adding 1½ pounds of sodium bicarbonate per 10,000 gallons of water until the desired level has been reached.

Higher levels of total alkalinity can cause "pH lock," which is what happens when the pH gets stuck at a certain level and is difficult to change. High total alkalinity can also cause scale to form and the water to become cloudy. To lower the total alkalinity, add sodium bisulfate or muriatic acid. This will also lower the pH. Locate the deepest part of the pool and, wearing protective gear, pour full strength muriatic acid into the water in a small area about the size of a basketball. The total alkalinity will "gas off" in this area, releasing CO_2, carbon dioxide. If during this application the pH is not lowered enough to form carbonate acid, no carbon-dioxide gas will escape and the total alkalinity will remain unchanged, but the pH will be lowered. With a larger pool, two or three areas may be lowered at one time. Several applications may be necessary. Repeat this procedure daily until the desired total alkalinity is obtained. Never add more than one quart of muriatic acid per 10,000 gallons of water.

If using sodium bisulfate, first mix with cool water and then apply to the pool in the same way as described for muriatic acid.



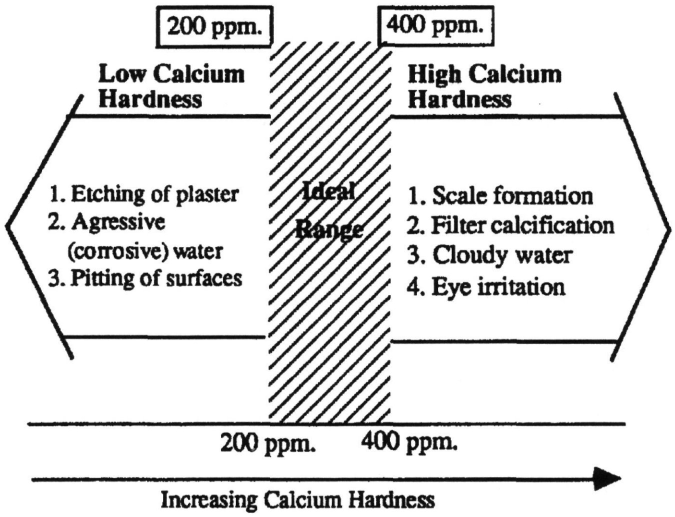
Total Hardness

Total hardness refers to water hardness. Calcium (Ca) and magnesium (Mg) are the primary ions contributing to water hardness with calcium accounting for 97% of the hardness. Other hardness contributors are iron (Fe) and aluminum (Al) but are generally ignored because they are easily removed in the water treatment process, or by the addition of sequestering agents. Swimming pools require hard water. Water with more than 100 ppm of hardness ions are called hard water.

Like pH and alkalinity, *calcium hardness* effects the tendency of pool water to be corrosive when it is low, and scale-forming when it becomes high. Only calcium ions combine with carbonate ions to form the calcium carbonates needed for water saturation. Therefore, as with pH and alkalinity, the pool operator must conduct tests for calcium hardness levels to determine the calcium factor (CF, which is used in the Langelier Saturation Index equation).

Generally, keep calcium hardness levels at 200 to 400 ppm. Generally, low calcium hardness presents a larger problem to pools than high calcium hardness does. If pH, total alkalinity, and calcium hardness are low, the corrosiveness and aggressiveness of the pool water will be greatly increased. This causes problems in deterioration of the pool walls and corrosion of metal parts. The calcium hardness values can be increased by adding *pharmaceutical grade* calcium chloride (not snow melter). Use 10 pounds of calcium chloride (80% $CaCl_2$) for each 10,000 gallons of water to raise the calcium chloride 80 ppm. Because calcium chloride produces a significant amount of heat, divide the total amount needed into two equal parts and apply to the pool in two applications.

While calcium hardness levels are typically maintained in the 200 to 400 ppm range they should not exceed 400-600 ppm, depending on the temperature and pH. If the calcium hardness reaches 600 ppm, make corrective adjustments. The exact values can be calculated using the Langelier Saturation Index. The only way to reduce excessively high levels of calcium hardness is to remove some of the pool water and replace it with fresh water. If the calcium hardness of your make-up water is high, water from another source may be necessary. Very often normal splash-out by swimmers and filter backwash procedures remove and replace enough water to maintain an acceptable calcium level. With high temperatures and excessive evaporation rates, additional water may have to be drained periodically to lower calcium hardness levels. Test for calcium hardness levels two to three times a month.



Total Dissolved Solids (TDS)

Nothing put into the pool water is one hundred percent soluble. Some chemicals react with water to form salt, while other chemicals stay in suspension. Others will form a light scale on pool surfaces, such as salt scale inside piping, or on the sand filter. The amount of material in suspension is referred to as total dissolved solids (TDS).

The National Swimming Pool Foundation suggests keeping the levels of TDS under 1500 ppm. With a TDS level of 2,000 ppm, the salt portion would be 17 pounds for every 1,000 gallons of water.As a comparison, salt water may have a TDS level of 35,000 ppm—350 pounds of salt for every 1,000 gallons of water!

All salt-like materials make balancing water chemistry difficult. It's like driving a car in heavy traffic—you know where to go but cannot get there because of all the obstacles in the way. When TDS are high, the pool water testing results will be erratic and unreliable and the water will look pale and cloudy. The only way to correct this problem is to dilute by adding fresh water.

Total dissolved solids can become so high that the pool and its components become saturated. This condition requires:

- Draining the pool,
- Scrubbing the walls and floors to remove the salt residue;
- Changing the filter sand;
- Replacing the filter cartridge or cleaning the earth elements.

Temperature

As water temperature increases, the water balance tends to become more basic and scale-forming. Conversely, as the temperature decreases, water becomes more corrosive. However, cince the temperature of pool water results from seasonal weather conditions or is selected to provide bather comfort, operators cannot adjust it to achieve saturation or balanced water. Due to temperature's effect on the corrosiveness or scale-forming properties of water, it is included as a factor in the Langelier Satruation Index (SI). Relatively speaking, however, temperature is the least significant factor affecting SI.

CHAPTER 6

Review Questions

Water Chemistry and Pool Water Balance

Write the answers to the following questions, then check your answers with those in the back of the manual.

1. What is the Langelier Saturation Index and what water characterisitc is it used to determine?

2. What parameters are involved in calculating the saturation index?

3. Using the Langelier Saturation Index, calculate if the pool water is either aggressive or scale-forming based on the following information:

   Swimming pool water has:

   - free available chlorine (F.A.C.) of 2.5 ppm,
   - total available chlorine (T.A.C.) of 3.0 ppm,
   - pH of 7.2,
   - total alkalinity is 75 ppm,
   - calcium hardness of 300 ppm,
   - temperature of 76° F.

4. Name 5 conditions that result from low pH (acidic) and 5 conditions from high pH water.

   Low pH-

   High pH-

5. How should muriatic acid be added to the pool?

6. How much undiluted muriatic acid would be used to lower the total alkalinity in a 50,000 gallon pool? (Add no more than 1 quart undiluted muriatic acid per 10,000 gallons of water.)

   a. 1 quart
   b. 2.5 quarts
   c. 5 quarts
   d. 10 quarts

7. What is the least soluble mineral found in water?

   a. Iron.
   b. Magnesium.
   c. Calcium carbonate.
   d. Aluminum.

8. Between what levels should the calcium hardness be maintained? Why?

   a. 50-200 ppm.
   b. 200-400 ppm.
   c. 400-600 ppm.
   d. 500-700 ppm.

9. What is the "salt-like material" that causes light scale to form on pool walls, inside piping, and on the filters?

   a. TDS (total dissolved solids).
   b. Algae.
   c. Soda ash.
   d. Filter sand.

CHAPTER 7

CHLORINATION OF POOL WATER

LEARNING OBJECTIVES

After completely studying this chapter, you should be able to:

- Define superchlorination, free available chlorine (F.A.C.), combined available chlorine (C.A.C.), and total available chlorine (T.A.C.).
- Explain what is meant by breakpoint chlorination.
- Calculate the amount of free chlorine residual necessary to raise the pool water to breakpoint chlorination.
- Compare available chlorine (disinfectant) residuals from different forms of chlorine, bromine, and cyanurates.
- Understand how the bacteria-killing efficiency of chlorine in pool water is dependent upon many factors.
- Calculate the amount of liquid chlorine used for superchlorination.

Chlorine Demand

Substances that contaminate or upset pool water chemistry continuously enter the pool from swimmers, air, the environment and other sources. These contaminants increase the chlorine demands on the water. To meet these demands, chlorine or other suitable disinfectant must be applied continuously.

Because the need for chlorine varies, the rate of application cannot be constant but must be adjusted to meet demand and to maintain a proper disinfectant residual. Testing water periodically for the chlorine residual is important since the frequency of adjustment depends on changing conditions. An example of a changing condition that might require additional chlorine is an increase in swimmers. Because of these changing conditions, MDEQ requires that the pool water be tested three times a day. If necessary, disinfectants can then be added to keep residuals at a level that provides disinfecting activity.

Chlorine *disinfects* or *sanitizes* water by destroying most harmful microorganisms, such as bacteria, fungi, and viruses. However, the water is not sterilized—that is, not all living organisms are destroyed. Chlorinating also helps control nuisance organisms such as algae, which may occur in the pool, filtration equipment, and piping. (Review chapter 3-Disinfectants).

Chlorine as Hypochlorous Acid (HOCl) and Hydrochloric Acid (HCl)

When chemical compounds of chlorine (Cl2) are added to pool water, **hypochlorous acid (HOCl)** and **hydrochloric acid (HCl)** form:

$$Cl_2 + H_20 = HOCl + HCl$$

The hypochlorous acid (HOCl) may then dissociate into hydrogen ions (H+) and hypochlorite ions (OCl-).

$$HOCl = H^+ + OCl^-$$

Both of these reactions are influenced by the pH of the pool water.

Factors Affecting Chlorine Efficiency

The disinfecting efficiency of chlorine in swimming pool water is dependent on several factors. Primary factors include:

1. Type of chlorine;
2. pH of pool water;
3. Water concentration of dissolved contaminants in the pool;
4. Water temperature;
5. Duration of contact between the disinfectant and the substance to be killed.

1. Type of chlorine. At a pH between 5.0 and 6.0, chlorine exists as hypochlorous acid (HOCl). Above pH 6.0, the HOCl dissociates and hypochlorite ions (OCl-) are present. At higher pHs of 7.2 – 7.5, the hypochlorite ions become more predominant and effective.

Chlorine existing in water as HOCl—hypochlorous acid—and OCl- —hypochlorite ions—is defined as **free available chlorine (FAC)**. Free available chlorine is the supply of HOCl which remains free to oxidize and sanitize impurities that enter the pool water. Once HOCl combines with impurities in the water, ammonia and other organic substances, it is no longer free available chlorine but forms **chloramines**. Chloramines are composed of waste products (e.g., ammonia or organic nitrogen) and have less than 1% of the sanitizing power of FAC. The combination of chlorine and ammonia is defined as **combined available chlorine**. In the combined form, it has an unpleasant odor and irritates eye and mucous membranes.

Free available chlorine is so much more effective as a disinfectant than combined available chlorine, that as much as 25 times more combined chlorine than free available chlorine may be needed to produce a 100% bacterial kill with the same contact time. The sum of these chlorine types—**free available chlorine** + **combined available chlorine**—is the **total available chlorine**.

When chlorine is applied to water, some combines with the impurities in the pool water as described above. The chlorine remaining is called the **chlorine residual**. The **chlorine demand** is defined as the difference between the amount of chlorine added to water and the amount remaining (the chlorine residual) at the end of these chemical reactions over a specific period. Chlorine residuals in pool water are expressed as parts per million (ppm) by weight, the term used to express low concentrations of chemicals or minerals found in a substance. Higher concentrations are expressed as parts per hundred and are generally given as percentages.

1% = 10,000 ppm

2. pH. In the normal, managable pH range of 7.2-7.6 for swimming pools, a decrease in the pH results in the formation of more hypochlorous acid (HOCl) and less hypochlorite ions (OCl-), which produces increased disinfection. See chapter three, Pool Disinfectants and pH, for more information.

3. Concentration of contaminants. An increase in chlorine consuming substances (impurities) or dissolved contaminants, requires an increase in the chlorine application rate to satisfy the chlorine demand and to disinfect the water. The filter equipment and filtration process helps reduce the amount of foreign substances suspended in the water and thereby reduces the water's chlorine demand.

4. Temperature. An increase in water temperature speeds up the chemical reactions which accelerates disinfection. However, it also increases the rate of chlorine consumption.

5. Duration of contact to disinfectant. The extent of bacterial kill is also increased by longer chlorine contact time. The chlorination process should precede and extend beyond each period of swimming pool use. The Michigan code requires that disinfection equipment run continuously—24 hours a day.

Superchlorination

Superchlorination (shock treatment) is required when undesirable substances are dissolved but not destroyed in the water. As discussed, chlorine combines with the dissolved contaminants to form odor producing **chloramines**. Superchlorination is the practice of adding 8-10 times the combined chlorine dose to reach **breakpoint** (see below) and reduce chloramines. Superchlorination or shock treatment, is also used for control of algae and other organisms resistant to normal disinfectant levels. A higher than normal residual of chlorine is necessary to "burn up" these undesirable materials in the pool water.

When the combined chlorine (chloramines) level reaches or exceeds 0.2 ppm, corrective action must be taken to lower it so that adequate chlorine residuals are effective disinfectants throughout the pool, and to ensure bather comfort. The accepted method for removing chloramines is known as ***breakpoint chlorination***. Breakpoint chlorination is also the method used for removing unwanted debris that causes cloudy water and promotes algae growth. Breakpoint chlorination is achieved by applying free available chlorine to the pool at the rate of 10 times the amount of combined chlorine in the pool. The calculations differ depending on whether you are using liquid or granular chlorine.

The first step in determining the necessity of a shock treatment is to determine the level of combined chlorine. Using the D.P.D. testing kit, test for free available chlorine (F.A.C.) and total available chlorine (T.A.C.). After completing the water test, your test kit directions instruct you to subtract the free chlorine reading from the total available chlorine reading, the result indicates the combined available chlorine (C.A.C.) or chloramine level in the pool water.

For example:

Total available chlorine
- Free available chlorine

Combined available chlorine

1.3 ppm (T.A.C.) measured from test kit
- 0.8 ppm (F.A.C.)measured from test kit

0.5 ppm C.A.C.

If the water has no chloramines, the answer to the subtraction will be zero (0) and a shock treatment is not needed. This is a desirable level.

After determining the level of combined chlorine in the pool water, the pool operator must determine the breakpoint chlorination for that value.

The formula for breakpoint chlorination using LIQUID chlorine (sodium hypochlorite) is:

$$\frac{\text{POOL VOLUME (in gallons)} \times 8.3 \times \text{COMBINED AVAILABLE CHLORINE} \times 1.0 \times 10}{1{,}000{,}000}$$

= Gallons of sodium hypochlorite needed to reach breakpoint chlorination

Volume of the pool in gallons, times 8.3 (weight of one cubic ft. water), times the combined chlorine level (total chlorine minus the free available chlorine) times 1.0 (lbs. of chlorine in one gallon of liquid chlorine) times 10 (ten times combined chlorine level) divided by one million to calculate the amount of **gallons of chlorine needed to reach breakpoint chlorination.**

The volume of the pool was calculated to have 450,000 gallons, and the combined available chlorine at 0.5 ppm. Therefore:

$$\frac{450{,}000 \times 8.3 \times 0.5 \text{ ppm} \times 1.0 \times 10}{1{,}000{,}000} = 18.7 \text{ gallons}$$

In this example, 18.7 gallons of sodium hypochlorite is needed to properly reach breakpoint chlorination.

NOTE: When shocking a pool, the chlorine-based chemical used for shocking the water must be added all at once so that the concentration throughout the pool reaches breakpoint chlorination.

The formula for breakpoint chlorination using GRANULAR chlorine (calcium hypochlorite) is:

$$\frac{\text{POOL VOLUME (in gallons)} \times 8.3 \times \text{COMBINED AVAILABLE CHLORINE} \times 1.5 \times 10}{1{,}000{,}000}$$

= Free chlorine residual needed to reach breakpoint chlorination in pounds of granular chlorine

Volume of pool water in gallons times 8.3 (weight of one cu. ft. of water) times combined available chlorine (C.A.C.) determined from the D.P.D. test kit times 1.5 lb.(weight of one pound of calcium hypochlorite) times 10 ppm representing 10 new, free available chlorine parts per million. Divide all the above by 1,000,000 to determine breakpoint in pounds of granular chlorine (calcium hypochlorite) needed.

For Example. A pool with 65,000 gallons of water tested to have:

2.0 ppm T.A.C.
- 1.0 ppm F.A.C.
1.0 ppm C.A.C.

Therefore,

$$\frac{65{,}000 \times 8.3 \times 1.0 \times 1.5 \times 10}{1{,}000{,}000}$$

= 8.1 pounds of granular chlorine to create free chlorine residual needed to reach breakpoint chlorination.

DESIRABLE CHLORINE LEVELS

	Chlorine	Bromine
Pools:	1.0 to 1.5 ppm	1.5 to 2.0 ppm
Spas:	2.0 to 3.0 ppm	3.0 to 4.0 ppm

Note: For these chlorine or bromine residual levels to be effective, the pH should be between 7.2 and 7.6.

If chloramines are present in pool water and the pool cannot be shut down to super-chlorinate, a product called **potassium mono-persulphate** may be used instead. Mono-persulphate is a strong oxidizer with no chlorine content. It oxidizes, or 'burns up' the contaminants that cause chloramines to form but does not increase the free available chlorine. For example, if the water tested has 1.0 ppm C.A.C., the pool operator will need to add one pound of potassium mono-persulphate per 10,000 gallons of water to remove the chloramine in the pool. Swimmers may remain in the pool because there is no increase in chlorine residual.

Chlorination Summary

Chlorination sanitizes and oxidizes organic impurities of swimming pool water. *A free chlorine residual* of 1.0 to 1.5 ppm is acceptable. However, combined chlorines should never exceed 0.2 ppm.

Keep the pool water pH between 7.2 to 7.6 to maintain chlorine control and efficiency. When a stabilized chlorine is used in an outdoor pool to protect against the sun's ultraviolet rays, the chlorine consumption is reduced by lowering the chlorine demand.

Summary Disinfectant Table

Chemical	Form	% Available Chlorine	pH of Solution
Chlorine			
Sodium hypochlorite	Liquid	12	13-14
Calcium hypochlorite	Granular or tablet	65	12-13
Chlorine gas*	Gas	100	0.2
Chlorinated Cyanurates			
Sodium dichloro-s-triazine trione	Granular	56	6-7
Trichloro-s-triazine trione	Tablet	90	2-3
Bromine			
(Bromo-chloro-dimethyl hydantoin)	Stick (tablet)	25 Cl/65 Br	6-7

*Use requires specific written approval.

CHAPTER 7

Review Questions

Chlorination of Pool Water

Write the answers to the following questions, then check your answers with those in the back of the manual.

1. When chemical compounds of chlorine are added to pool water, what chemicals are formed?
   a. Hypochlorous acid (HOCl).
   b. Hydrochloric acid (HCl).
   c. Both of the above.

2. Define "combined available chlorine." How is combined available chlorine different than total available chlorine?

3. Which form of chlorine is the most effective for killing bacteria and disinfecting the pool water?
   a. Free available chlorine.
   b. Combined available chlorine.
   c. Total available chlorine.
   d. Chloramines.

4. Define "super-chlorination" and describe when is it done?

5. What is the formula for achieving breakpoint chlorination using liquid chlorine?

6. Given total available chlorine equal to 1.5 ppm, and free available chlorine equal to 0.7 ppm, what is the combined available chlorine of a 120,000 gallon indoor swimming pool? (FAC + CAC = TAC)

7. Using the chlorine information from the above problem, calculate how many gallons of chlorine are needed to reach breakpoint chlorination using liquid chlorine.

$$\frac{\text{Pool Gallons} \times 8.3 \times \text{CAC} \times 1.0 \times 10}{1{,}000{,}000}$$

8. Can potassium mono-persulphate be used to shock the pool water if swimmers are present?

9 Which chlorine product has a greater percentage (%) of available chlorine: trichloro isocyanurate (cyanuric acid and chlorine) or granular calcium hypochlorite?

CHAPTER 8

RECIRCULATION AND FILTRATION SYSTEMS

LEARNING OBJECTIVES

After completely studying this chapter, you should be able to:

- Calculate pool volume.
- Understand the flow of water to and from the pool.
- Calculate the flow rate of a swimming pool.
- List the flow rates for the various types of filters.
- Explain why "backwashing" is necessary for proper recirculation and filtration.
- Compare the different types of filtration systems.
- Explain the purpose of flocculants.

Before any water treatment, chemical adjustment, or evaluation of a problem, the pool operator must know how much water is in the pool. This is determined by calculating the volume of water in the pool.

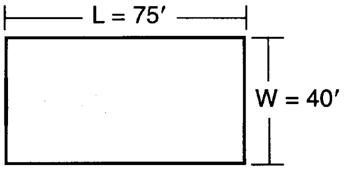
To determine the amount of water in your pool, use formulas that match the shape of the pool. The first step in calculating volume is to calculate area. Once the surface area of a pool is known, it is multiplied by depth to determine volume.

Calculating the Area of Pools

Regularly Shaped Water Bodies

Rectangles – The area of a rectangle is found by multiplying the length (L) by the width (W).

Area = length × width



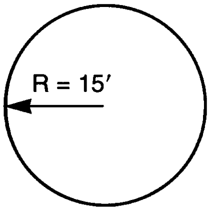
Example:

L = 75 feet — Area = 75 ft. × 40 ft.

W = 40 feet — Area = 3,000 sq. ft.

Circles – The area of a circle is 3.14 (π) times the radius (half the diameter) times the radius.

Area = πr^2 OR **3.14 × radius × radius**



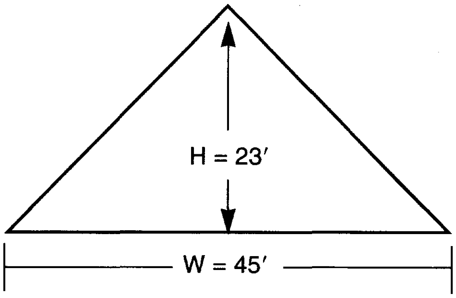
Example:

r = 15 feet — Area = 3.14 × 15 ft. × 15 ft.

Area = 706.5 sq. ft.

Triangles – To find the area of a triangle, multiply the width at the base (W) by the height (H), and divide by 2.

$$\text{Area} = \frac{W \times H}{2}$$



Example:

W = 45 ft.

H = 23 ft.

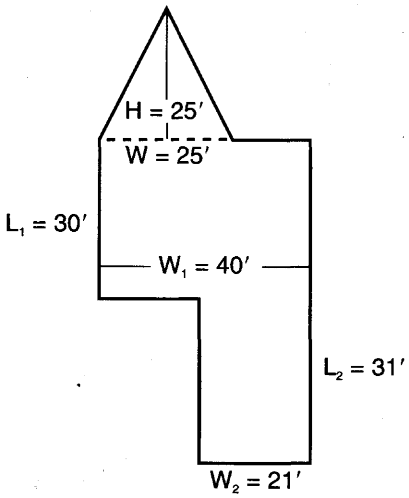
$$\text{Area} = \frac{45 \text{ ft.} \times 23 \text{ ft.}}{2}$$

Area = 517.5 square feet

Irregularly Shaped Sites

Irregularly shaped pools often can be reduced to a combination of rectangles, circles and triangles. Calculate the area of each and add them together to obtain the total area.

$$\text{Area} = \frac{(W \times H)}{2} + (L1 \times W1) + (L2 \times W2)$$



Example:

W = 25 feet	W_1 = 40 feet
H = 25 feet	L_2 = 31 feet
L_1 = 30 feet	W_2 = 21 feet

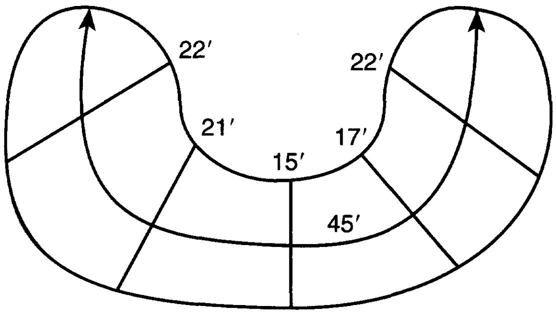
$$\text{Area} = \frac{(25 \text{ ft.} \times 25 \text{ ft.})}{2} + (30 \text{ ft.} \times 40 \text{ ft.}) + (21 \text{ ft. x } 31 \text{ ft.})$$

Area = 312.5 sq. ft. + 1,200 sq. ft. + 651 sq. ft.

Total area = 2,163.5 sq. ft.

Another way is to establish a line down the middle of the pool for the length, and then measure from side to side at several points along this line. pools with very irregular shapes require more side-to-side measurements. The average of the side measurements can be used as the width. The area is then calculated as a rectangle.

$$\text{Area} = \frac{L \times (a + b + c + d + e)}{\text{number of side-to-side measurements}}$$



Example:

L = 45 feet	c = 15 feet
a = 22 feet	d = 17 feet
b = 21 feet	e = 22 feet

$$\text{Area} = \frac{45 \text{ ft.} \times 22 \text{ ft.} + 21 \text{ ft.} + 15 \text{ ft.} + 17 \text{ ft.} + 22 \text{ ft.}}{5}$$

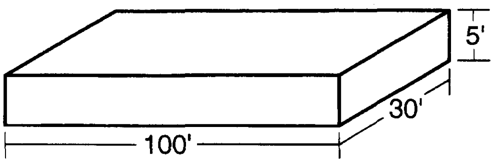
Area = 873 square ft.

Calculating Volume of Pools

To treat bodies of water, you must determine the volume of the water. Volume of water is determined by multiplying the surface area by the depth. Irregularly shaped pools will often be a combination of shapes. Similar to what you did in the previous examples for finding the area of irregularly shaped pools, reduce the pool to a combination of rectangles, circles and triangles. Determine the area, and multiply the area by the depth to calculate the volume. With irregularly shaped pools, add the volume of each section together to obtain the total volume.

Pools Shaped Like Cubes or Boxes – The volume of a cube or box is found by multiplying the length (L) by the width (W) by the depth (D).

$$\text{Volume} = \text{length} \times \text{width} \times \text{depth}$$



Example:

l = 100 feet w = 30 feet d = 5 feet

Volume = 100 ft. x 30 ft. x 5 ft.

Volume = 15,000 cubic ft. (feet3)

One cubic foot = 7.48 gallons of water. Therefore, 15,000 x 7.48 = 112,200 gallons of water in this rectangular pool.

For accurate calculations, divide the pool into various areas according to depth. If the slope of an area is constant, an average of the shallow depth and deepest depth may be used. To calculate volume in varying sloped pools, determine the volume in sections that do have constant slopes and add together.

Example:

$$\text{Volume} = \text{length} \times \text{width} \times \frac{(\text{depth}_1 + \text{depth}_2)}{2}$$

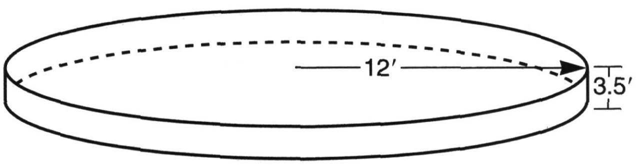
$$40 \times 20 \times \frac{(6+3)}{2} = 3{,}600 \text{ cubic ft.}$$

3,600 cubic ft. × 7.48 gallons/cu. ft. = 26, 928 gallons

Shaped Like Cylinders

The volume of a cylindrical pool or spa is found by multiplying the depth by the area of the circle at the base. The area of the circle is the radius (half the diameter) times the radius times 3.14.

Volume = depth x 3.14 x radius x radius



Example:

depth = 3.5 feet radius = 12 feet

Volume = 3.5 ft. × 3.14 × 12 ft. × 12 ft.

Volume = 1,582.5 cubic ft (feet3)

1,582.5 cu. ft. × 7.48 gallons/cu. ft. = 118,371 gallons

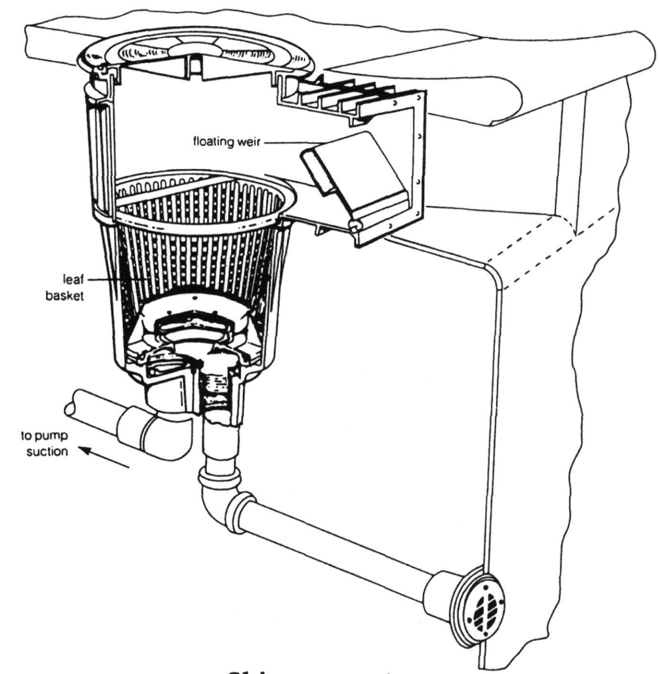
Pool Filter Systems and Operation

Public swimming pools, spas, wading pools, wave pools, etc. are required to have the water recirculated continuously, 24 hours a day. A series of **drains** and **skimmers** move the water from the pool through the **hair and lint strainer, pump, filter, heater,** and return the water back to the pool through small openings, called **inlets**, in the pool wall and sometimes in the floor.

Skimmers

The pool is designed so that the water level and cleanliness level remain fairly constant. Water is delivered to the filters either drawn through several openings in the pool wall called **skimmers** or from an overflow system in the gutter that extends around the pool perimeter. These devices are designed for moving water at a specific rate along the piping to the pump.

Frequently clean the skimmers and grates in the overflow gutters to ensure that larger debris is removed before reaching the hair and lint skimmer. Many of these surface skimmers are the connection points for the vacuum cleaning systems for the pool. On the skimmer opening is a moving part called the weir or gate. The weir keeps larger floating materials confined in the skimmer so they can be easily removed.



Skimmer system

Filtration

The physical removal of dirt and debris from pool water is called filtration. Only pool water should be returned to the filtration equipment from the skimmers and main drains of the pool, i.e., no water from the decks, drinking fountains, or any type of dehumidifying equipment is allowed to drain back into the pool water.

Pool water travels within a closed loop of piping through the hair and lint strainer where the larger debris in the water is removed before reaching the pump. Water is said to be under **suction** from the pool, through the hair and lint strainer, then into the pump and attached impeller. After the pump, water is said to be under **pressure** when moving through the filter, heater and piping back to the pool.

The chemical feeder of disinfectants is attached to the filtration system. The pool filter not only helps clean the water of algae and smaller particulate matter, but also mixes the disinfectant with the water. Without a clean and properly functioning filtration system water clarity is impaired.

Turnover Rate

All of the water in the pool must be filtered within a specified time period. This is called the **turnover rate**. The clarity of typical public swimming pool water is optimal when the turnover rate is between 6-8 hours. Other pools have different rates dependent upon their size, type and volume. For example, spa pools and wading pools usually have a turnover rate of 1 hour or less, while for wave pools it is 4 hours or less.

For a swimming pool, there may need to be several turnovers during the 24 hour period since only 68% of the contaminants are removed in 6-8 hours. In two turnover periods (12-16 hours) approximately 96% of debris is removed. Only a very small amount of material remains after 24 hours (less than 0.5% is not removed).

To calculate the turnover rate of a pool in gallons per minute (gpm), use the following formula with the specific volume of your pool.

Required flow rate in gallons per minute = volume/divided by time

For example, if a pool has a volume of 36,000 gallons and the required turnover rate is 6 hours:

$$\text{FLOW RATE} = \frac{\text{VOLUME}}{(\text{HOURS}) \times (60 \text{ min./hr})}$$

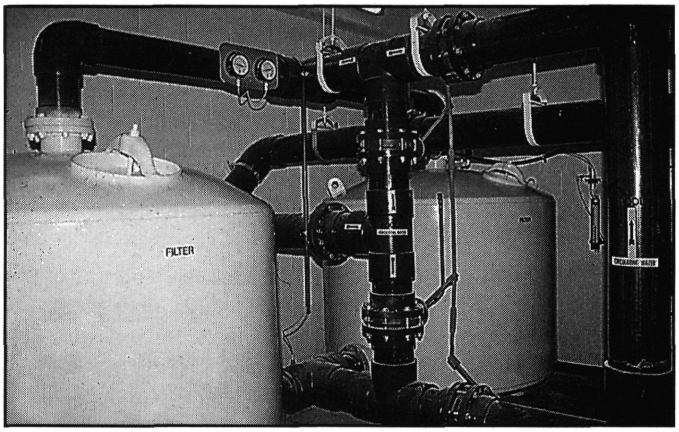
$$\text{Flow Rate} = \frac{36{,}000 \text{ gal}}{6 \text{ HRS} \times 60 \text{ min./hr}}$$

$$\text{Flow Rate} = 100 \text{ G.P.M.}$$

Therefore, if 100 gallons of water per minute (gpm) passes through the filter, all the water in the pool will be recirculated in 6 hours.

Filter Area

Each type of filtration system allows water to pass through the filtering media at a specific rate —**filter rate**—measured in gallons per minute (gpm) per square foot of filter area. For example, a high rate sand filter could have a filter rate of 12 to 20 gpm per square foot of effective filter surface area. See Table One. A cartridge system, by comparison, would have a flow rate of 0.375 gpm per square foot of surface area.



Sand filter system.

Filters are sized according to the volume of water that needs to be filtered within the specified turnover rate. A pool volume of 36,000 gallons with a desired turnover rate of 6 hours, or 100 gpm, would need a *high rate sand filter* with approximately 7 square feet of filter surface area. First, divide the pool volume by the **desired turnover rate** to determine flow rate (36,000/6 hrs x 60 min/hr = flow rate). Next, divide the flow rate by the appropriate filter flow rate per square foot (from Table One.) to determine the size of the filter surface area needed, i.e., 100 gpm flow rate divided by 15 gpm/sq. ft. = 6.67 or 7 sq. ft. of filter surface area.

Table One. Filter flow rates for various types of filters

Vacuum sand filter	0.5 gpm/sq. ft.
Rapid sand filter	3.0 gpm/sq. ft.
High rate sand filter	12-20 gpm/sq. ft. (15 gpm/sq. ft. ideal)
D.E. filter(s)	2.0 gpm/sq. ft.
Cartridge filter	0.375 gpm/sq. ft.

Filter Media and Backwashing

The ability of the filter to trap and hold particulate matter from the pool water is dependent upon the size and type of media (filter substrate). A finer, smaller material such as diatomaceous earth (D.E.) will trap a greater amount of debris compared to sand media or the paper mesh of a cartridge filter.

When the filter media is clean there is little resistance against the water. However, when the filter gets dirty, the flow rate slows and filtering becomes less efficient, possibly causing cloudy water, algae build up, and more contaminants remaining in the pool water. Cleaning the filter media by mechanical or physical methods is called **backwashing**.

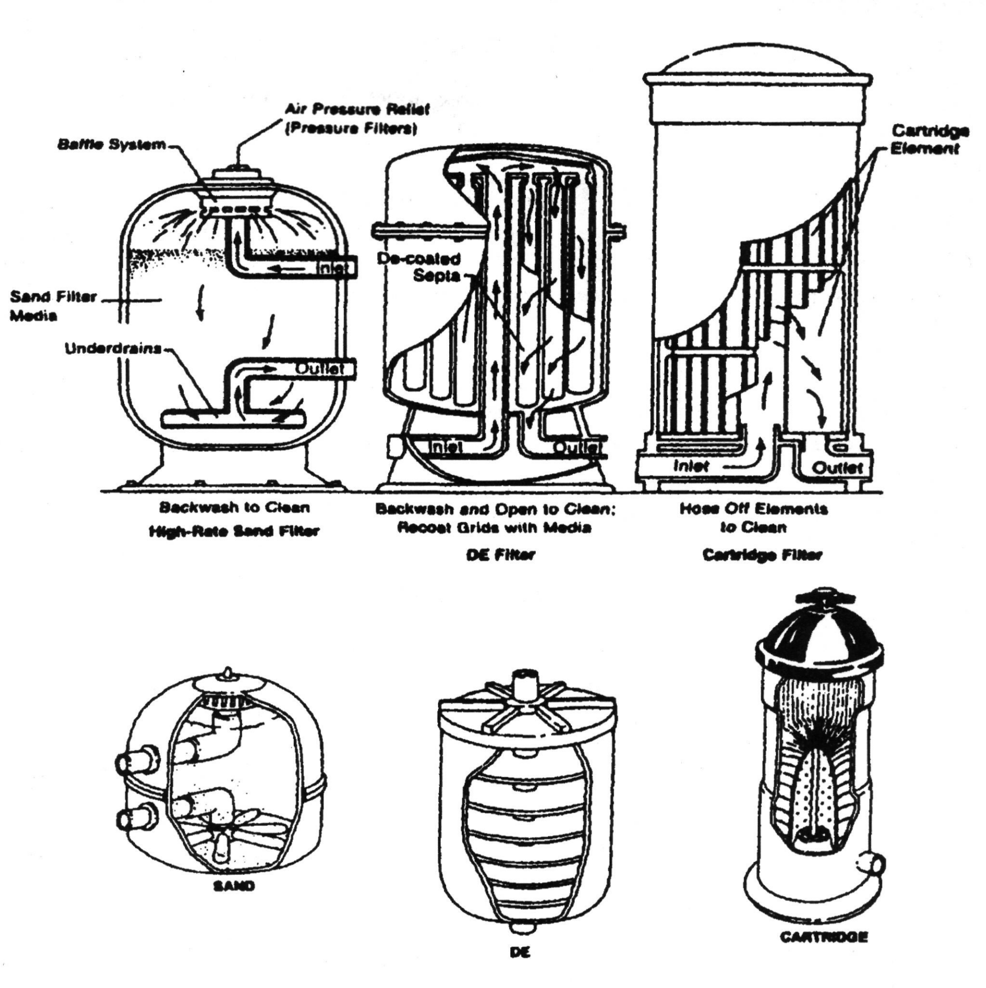
Backwashing sand filter systems usually involves reversing the flow of water through the filters by turning a valve or control lever to a backwash position. The reverse flow loosens the dirt in the filter media and rinses the debris to waste (eliminated from the system). In a diatomaceous earth (D.E.) filter system, the filter grids would be washed of D.E. powder during the backwash procedure and require recoating before reuse. Cartridge filters must have the entire mesh or woven element replaced with a cleaned or new unit.

Backwashing requires that a specific flow rate is maintained during the procedure. Usually the rate is 12 to 15 gpm/sq.ft. for sand filters. Backwashing should be performed when the:

- incoming (influent) pressure is 10-12 psi greater than the pressure on a clean filter,
- flow rate decreases due to resistance in the dirty filter,
- pool water becomes cloudy and debris remains in the water.

High Rate Sand Filter

In high rate sand filters, to be effective, the filter needs a specific sand size to filter particulate matter in the pool water. The sand is packed around a series of finger-like projections called laterals or elements housed in a tank into which the water enters. The incoming water from the pool enters through these laterals and is discharged upward where it is reflected off the top of the tank cover and flows downward. This downward flow of the water inside the tank helps to prevent channeling and migration of the sand. Should channeling occur, the water will pass through the channel without being properly filtered.



Examples of Pool Filter Systems.

An open space between the top of the tank and the top of the sand inside the tank is called the **freeboard**. The freeboard is usually 12 inches or more and must exist for the sand to "tumble and fluff-up," causing the debris to loosen for backwash removal.

On the outlet (effluent) pipe, a pressure gauge is mounted. This gauge measures the pressure in the system of the "clean and filtered" water emerging from the filter, which should be lower than the influent gauge reading. Typically, the difference between the influent and effluent pressure gauges should not be more than 12-15 psi. Some filter equipment may have a higher differential based on the pool design.

Backwashing of the high rate sand filter for a time period of 2-3 minutes is recommended. Once the water discharge is clear, the backwashing is complete. Reposition the lever or handle of the backwash valves to a "filter run" position. If sand is found entering the pool through the inlets of the pool wall, there may be either a cracked or broken lateral, or the lever on the filter for backwashing may not be properly set in place.

Filter aids, or **flocculants**, are sometimes used for trapping surface dirt on the sand. Flocculants may not be recommended for use by the filter manufacturer since the filter will have an increased pressure from the restricted (clogged) surface. The use of D.E. powder in the filter is not recommended as a routine method of cleaning the pool of debris. D.E. may offer a temporary relief, while masking a significant filter problem. The filter size, pump impeller, or the entire circulation system may need to be re-evaluated to determine if it meets the cleaning demands of the pool size and volume of use.

Vacuum Sand Filters

The vacuum sand filter is not used as much as in previous years due to the inefficiency of the system. However, many older, community pools may have this type of filtration equipment. Filter rates are low at about 0.5 gallons of water per square foot of surface area, therefore more space is required for this open tank, gravity system. These systems allowed the operator to observe flocculation and possible channeling of the sand. Most vacuum sand systems have been replaced with newer high rate sand filters.

CHAPTER 8

Review Questions

Recirculation and Filtration Systems

Write the answers to the following questions, then check your answers with those in the back of the manual.

1. Calculate the pool volume in gallons if a 25′ x 50′ pool has a shallow end of 3 ft. and a deep end of 7 ft.

2. Explain the flow of water away from the pool and back into the pool. Underline key components of the system.

3. Calculate the flow rate in gallons per minute (gpm) of a 40,000 gallon pool requiring a 6 hour turnover. Also calculate for a pool requiring an 8 hour turnover rate.

$$\text{Flow rate} = \frac{\text{volume}}{\text{hours} \times 60\ \text{minutes/hour}}$$

4. What is the "filter flow rate" of a high rate sand filter? Is there an ideal filter flow rate? If so, what is it?

5. D.E. filters have a filter flow rate of 2.0 gpm/square ft. How much D.E. filter area is needed in a 36,000 gallon pool for a 6 hour turnover rate?

Table One. Filter flow rates for various types of filters.

Vacuum sand filter	0.5 gpm/sq. ft.
Rapid sand filter	3.0 gpm/sq. ft.
High rate sand filter	12-20 gpm/sq. ft. (15 gpm/sq. ft. ideal)
D.E. filter(s)	2.0 gpm/sq. ft.
Cartridge filter	0.375 gpm/sq. ft.

$$\frac{\text{Pool volume in gallons}}{\text{turnover rate (60 min/hr)}} = \text{Flow rate gpm}$$

$$\frac{\text{Flow rate gpm}}{\text{Filter flow rate/sq. ft.}} = \text{square feet of filter area}$$

6. List 3 conditions that indicate that a pool should be backwashed.

7. Should flocculants be added to the pool frequently? Why or why not?

8. Are vacuum sand filters economical? Why or why not?

9. How do you calculate the area of the following?
   Circle:
   Triangle:
   Rectangle:
   Circle:
   Area :
   Triangle:

10. How do you calculate the area of an irregularly shaped pool?

11. How do you calculate the volume of water in a spa shaped like a cylinder?

CHAPTER 9

CARTRIDGE AND DIATOMACEOUS EARTH (D.E.) FILTERS

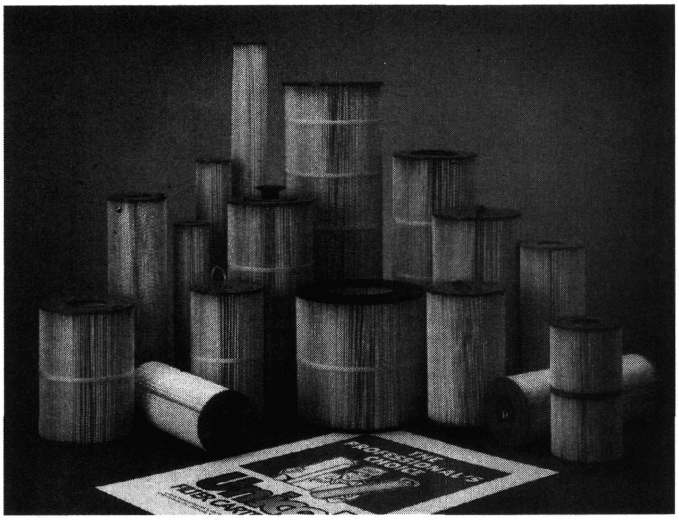
LEARNING OBJECTIVES

After completely studying this chapter, you should be able to:

- List the advantages of cartridge filters compared to sand or D.E. filter systems.
- Understand and list the cleaning methods of cartridge elements.
- Explain the effect of hot tub water temperatures, the release of body oils and the implications for cleaning the pools' filters.
- Calculate the amount of D.E. powder necessary for precoating a filter.
- Understand how diatomaceous earth filters trap dirt and debris.
- List conditions or problems that shorten the filter cycle of operation.
- Explain how to correct filtering problems that interfere with proper operation.
- Understand why it is necessary to stop the pump when changing valves or settings on a D.E. filter system.

Cartridge Filters

Cartridge filters for pools are relatively new in the marketplace. They are usually installed on smaller, spa/hot tub installations but can be used for swimming pools. Cartridge filters are constructed of a fiber material, which is very effective in removing dirt and suspended matter when water passes through it.



A few standard sizes and shapes of swimming pool cartridge filters.

The single-element cartridge filter adds an entirely new dimension to swimming pool filtration and offers some unique features that are not available in either high-rate sand or DE filters. Some of these features are as follows:

1. Compact, lightweight, easy to install, and no backwashing required.
2. More effective filtration area in a very compact system.
3. Less maintenance and longer filter runs between cleaning.

Sizing Cartridge Filters

The only definite size standard that has been set pertaining to the use of cartridge filters on commercial pools is that of the National Sanitation Foundation (NSF).

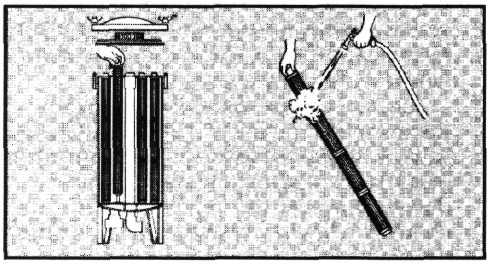
The NSF Standard for commercial pools specifies a flow rate of 0.375 gallons per minute for all cartridge filter types. Flow rates greater than 0.375 gpm through a cartridge filter reduces the filter cycle and therefore reduces filtration effectiveness.

Cleaning Cartridge Filter Elements

Normally, the fiber elements of cartridge filters can be cleaned by simply applying water to the element from a hose and nozzle. However, improper pool water chemistry can produce problem conditions. Visually inspect filter cartridges and check for build-up of contaminants by feeling the surfaces on a regular basis. When a filter element becomes contaminated with algae, calcium carbonate, iron or binders used in chlorine tablets, special cleaning procedures must be performed. When problems of this nature occur, the following steps are recommended:

1. Remove accumulated dirt by washing the element using a hose and nozzle.
2. Remove oils and other debris by soaking the element for one hour in a solution comprised of one cup of automatic dishwasher detergent mixed with five gallons of water.
3. While wearing personal protective equipment, mix a solution of four cups of muriatic acid with five gallons of water in a plastic container. Allow the filter element to soak for approximately four hours. Thoroughly rinse the element in a solution composed of 0.1 pound of soda ash per one gallon of water. This neutralizes the acid residual remaining on the element.
4. Keep a complete set of spare clean filter elements available at all times. This will ensure that filtration will not be interrupted between cleaning processes.

NOTE: Never use a brush to scrub the surface of the element.



Many pool operators keep two complete sets of cartirdge filters on hand. When one set gets dirty, put the second set into the filter and clean the dirty set when time is available. This eliminates filter down-time.

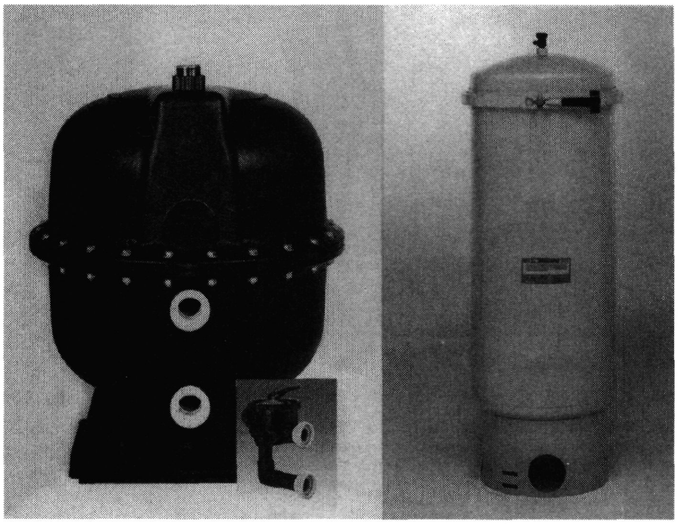
Cartridge Filters Used for Spas and Hot Tubs

Cartridge filters used in spas and hot tub installations are subjected to a higher concentration of body oils than those used in swimming pools. Spas and hot tubs operate at temperatures that are approximately 25 degrees Fahrenheit higher than that of swimming pools. This elevated temperature causes a greater amount of body oil to be released and into the water. As a result, cartridge filters used on spas and hot tubs will require more frequent cleaning than those used on a swimming pool. Failure to provide more frequent cleaning will result in severe clogging of the element.

Diatomaceous Earth (D.E.) Filters

Diatomaceous earth (D.E.), also called "diatomite", is a white, odorless silica powder originating from skeletons of microscopic single-cell plants. These single-celled plants—diatoms—flourished about 15 million years ago in certain bodies of water. Properly applied to the pressure side of filter elements, it forms a porous, relatively non-compressible coating through which water readily passes. Dirt particles, lint, hair, certain bacteria and protozoa, as well as other suspended impurities, do not pass.

To form this coating on the filter element, diatomite powder is added to the water flowing through the filter tank, where it is trapped on the screen (grids or elements) as a uniform "precoat" about 1/16- to 1/8-inch thick on every part of each filter element. This coating of "filter cake" is the filtering surface that entraps suspended particles, holding them until the filter is backwashed. After backwashing, the "filter cake" is then discarded and replaced with fresh diatomite. Remember that the principal purpose of filtration is the removal of suspended dirt. It is not a substitute for proper disinfection and chemical treatment of the pool water.



D.E. filters are special tanks containing a series of covered filter grids. Diatomaceous earth is introduced into the filter by the pump and covers the filter elements. The D.E. allows water to pass through but collects the smallest of suspended dirt particles. When cleaning is needed, the water flow is reversed (backwashing) and the dirt and D.E. are sent to a waste line.

Whether the D.E. filter system is of the pressure or vacuum type, the water flow is first through the filter cake, then through the filter elements, finally to the clean-water effluent piping. Because many models and types of filters are marketed and approved for use, check the manufacturer's instruction list and data plate on the tank for the information needed to follow these basic procedures:

- Prime the pump before starting the filter. Run the pump to fill the filter tanks with water, and then open the air vent (if provided) or otherwise bleed all air from the top of the tank.
- Follow the instructions for precoating using 0.125 pounds (or 2 oz.) of diatomite per square foot of filter surface area. For example, a 50 sq.ft. filter would need 50 sq.ft. x 0.125 lbs. = 6.25 pounds. Measure the diatomite using a container such as an empty one-pound coffee can (this holds about 7 or 8 ounces of diatomite).
- Make a slurry by premixing the required amount in a bucket and stirring the powder into a convenient quantity of water.
- Set the filter control valve or effluent valve to "recirculate," or, if not provided, set to "filter to waste" or "rinse." Be sure to stop (turn off) the pump when changing valves. Never close all valves at the same time because it could damage the pump or filter.
- Do not allow the filtered water to return to the pool until it runs clear: the flow of filtered water for the first 15 to 30 minutes after precoating may contain enough fine particles of diatomite to cause cloudiness in the pool.Unless it is time to backwash the filter, never stop the pump for any reason. Any interruption of water flow will allow part or all of the diatomite coating to drop off the filter elements. If this happens, filtration stops and the effluent is just as dirty as the unfiltered water because all or most of the water passes through the uncoated areas of the filter.

Backwash pressure-type diatomite filters when the influent and effluent gauges show 10 to 20 psi pressure differential (vacuum filters, about 10 to 15 inches of mercury vacuum), depending on the original design. Several factors can shorten the filter cycle or length of time that the filter can be operated between backwashes, including:

1. A heavy dirt load in the pool, such as debris falling or being blown into the water, or an unusually large number of poorly showered bathers.
2. Wrong grade or quantity of diatomite filter-aid being used. Check the manufacturer's instructions. Never cut back on the recommended amounts; this will add to the cost of maintenance in the long run.
3. Clogged hair strainer or skimmer baskets.
4. Partial loss of coating on filter.
5. Accumulated grease, hair, oil, suntan lotion, algae cells, or any slime and dirt clogging the filter elements. Chemical cleaning with tri-sodium phosphate and or muriatic acid may be needed to remove them.
6. Inadequate backwashing, leaving part of the old filter-aid coating in place. In extreme cases, this may require disassembly of the filter to dislodge the accumulation of debris by using a strong water jet or gently removing it with a wooden stick.
7. Damaged gaskets, elements or other internal parts can permit filter-aid and dirt to pass through the filter grids causing cloudy water.
8. Compaction of filter-aid coating due to excessive flow rate. Watch the flow meter and pressure gauges and adjust valves, as necessary, to maintain the design flow rate. Compaction can be slowed by the continuous addition of filter-aid ("body feeding") at a slower rate, about one to five pounds of diatomite per 100,000 gallons of water through the filter. (A 36,000 gallon pool with a 6-hour turnover would then need about 1-5 ounces of powder per hour, depending on the dirt load in the water). This creates a clean, prime filtering surface preventing sliding and or a rapid increase in pressure differential.
9. Air-binding of the filter tank, preventing proper precoating of the entire surface of each filter element.
10. Calcium deposits on filter elements, reducing the available screen area. When the pH rises above 7.8, the dissolved calcium is likely to precipitate on the elements. This may necessitate disassembly of the filter and cleaning the elements. Check the manufacturer's recommendations before attempting this procedure.
11. Undissolved particles of calcium hypochlorite accumulating in a glaze over the surface of the filter-aid coating, cutting off the flow. All such compounds should be completely dissolved before being added to the pool to prevent any insoluble residue from entering the pool.
12. Improper chemicals being used, such a alum, which is a filter aid for sand filters but is NOT to be used in a diatomite filter.
13. Inadequate disinfectant (chlorine, etc.) being used, allowing bacterial or algae slime to interfere with proper precoating.

The need to correct each type of difficulty suggested above is usually self-evident. For further detailed information, consult the instructions furnished by the filter manufacturer.

CHAPTER 9

Review Questions

Cartridge and Diatomaceous Earth (D.E.) Filters

Write the answers to the following questions, then check your answers with those in the back of the manual.

1. Name three advantages that cartridge filters have over sand filter or D.E. systems.

2. What is specified filter flow rate for cartridge filters as established by National Sanitation Foundation (NSF)?

   a. 5 gallons/minute/square ft. of surface area

   b. 3 gallons/minute/square ft. of surface area

   c. 1 gallons/minute/square ft. of surface area

   d. 0.375 gallons/minute/square ft. of surface area.

3. List the four-step procedure for cleaning cartridge filter elements.

4. What effect does spa pool water have on cartridge elements?

5. Explain why D.E. powder stops more dirt and debris than a sand filter.

6. How much D.E. powder is needed for 75 sq. ft. of filter surface area?

7. What happens if filtered water has too much D.E. powder in it?

   a. It may encourage algae to grow.

   b. The pool could turn cloudy from the fine particles of diatoms.

   c. Swimmers skin and eyes will be irritated.

   d. The pH will fluctuate until the D.E. precipitates.

8. What could happen if the valves were not closed or the pump is not turned off when switching operation modes?

9. List seven problems or conditions that cause a shortened D.E. filter run.

10. From the above listing of problem conditions, choose four problems and explain how to correct the situation.

CHAPTER 10

WADING POOL MAINTENANCE

LEARNING OBJECTIVES

After completly studying this chapter, you should be able to:

- Calculate required quantities of disinfectants for wading pools.
- Understand why wading pools present more of a health hazard than larger swimming pools.
- Explain the importance of a proper flow rate and disinfectant level in a wading pool.
- List what steps need to be taken when a wading pool becomes contaminated.

Proper care of a public wading pool requires management practices similar to those required at full-scale public swimming pools-carefully engineered, operated, and supervised to keep health and accident hazards to a minimum. Check wading pools at least three times per day. Water chemistry, filter flow rate, water clarity, number of users and general appearance checks are required due to the ratio of heavy demands to the amount of water per user. Changes occur quickly, and, if trends are not observed and steps taken, the situation can turn into a very serious or costly one. The water in these pools is kept in satisfactory condition by being recirculated, filtered and disinfected continuously while in use. Requirements include personal cleanliness of the pool users, proper sanitation in the pool area and continuous operation of the pool filter system.

Enclosures

Enclose the wading pool area with a fence, equipped with a self-closing gate. Keep gates in good repair and workable at all times. If the pool is not drained daily, close and lock the gate when the area is not in use.

Water Circulation and Flow Rate

Wading pools are equipped to provide a continuous, uniform circulation of treated (disinfected) water within the pool. All water within a wading pool must be disinfected every 2 (two) hours. To achieve this water turnover rate, an adequate amount of pool water must flow over the disinfectant to clean the contaminated water. To keep water flow from being hindered, keep drains clean and clear of any debris.

Disinfecting Wading Pool Water

A suitable disinfectant level must be maintained throughout the pool water. The water is treated by the flow of pool water over the chemical disinfectant tablets or through a liquid chlorine feeder. The minimum disinfectant levels for different pH (amount of acidity or alkalinity in the water) ranges are:

CHLORINE LEVEL 0.4 PPM WHEN pH = 7.2 – 7.6

CHLORINE LEVEL 1.0 PPM WHEN pH = 7.7 – 8.0

It is strongly suggested that when chlorine levels reach 0.4 ppm or below, additional disinfectant be *immediately* added to raise the chlorine level to 1.0 ppm. When adding any chemical to the pool, bathers must not use the pool until the chemical has been evenly distributed and acceptable disinfectant and pH levels have been achieved-usually 45 minutes to 1 hour. Verify your residual levels using a reliable chlorine test kit.

Testing the Water and Operational Reports

Test pool water frequently (suggested 3 times daily). The disinfectant levels and pH are then adjusted, if necessary. Record this information on the monthly operational reports that are submitted to the local health department.

Contamination of Wading Pool Water

Due to the young age of bathers using wading pools, the likelihood of contamination from bowel movements and lack of bladder control is high. When the water is contaminated by feces, urine or other debris, drain the pool, scrub with a disinfectant, and then thoroughly rinse and refill before use.

To prevent injuries, immediately remove any physical contamination such as glass, metal or similar debris. Do not allow pets or animals in the pool or enclosed area at any time. Keep the adjacent toilet facilities clean, in working order and properly equipped.

General Maintenance

Periodically clean the chemical tablet reservoir, feeder, screen, or tube to remove the build up of unused disinfectant. If the screens and tubes are clogged, broken, or missing from the disinfectant reservoir, replace them as soon as possible. **Children must not be able to reach these chemical tablets.**

Keep the interior pool structure smooth, nonabsorbent and in good repair to prevent accidents. Drain covers must be properly sized and secured to prevent users from placing debris in the drains and to avoid having body parts or hair sucked into the drains or skimmer from recirculation pressure.

Supervision

Due to the young age of the bathers using wading pools, it is advisable to always have at least one attendant or responsible adult within the pool enclosure to supervise the bathers' activities. Attendants should be alert for

any potential for accidents, injury or problem affecting the health and safety of the bathers.

It is recommended to have any child wearing diapers use cloth diapers with a plastic pant over them to prevent contaminating the pool water with solids. Disposable diapers can break apart in the water and should not be worn in a public pool.

Bathers with infectious or communicable diseases, or conditions such as a cold, flu, skin eruptions, open blisters or inflamed eyes should be excluded from the wading pool. Have a well stocked first aid kit available in case of injuries.

CHAPTER 10

Review Questions

Wading Pool Maintenance

Write the answers to the following questions, then check your answers with those in the back of the manual.

1. What is the recommended turnover rate for a wading pool?
   a. One hour.
   b. Two hours.
   c. Three hours.

2. What is the minimum disinfectant (available chlorine) level for a wading pool when the pH is 7.8?
   a. 4.0 ppm available chlorine.
   b. 3.0 ppm available chlorine
   c. 2.0 ppm available chlorine
   d. 1.0 ppm available chlorine.

3. What is the minimum disinfectant (available chlorine) level for a wading pool when the pH is 7.2?
   a. 1.0 ppm available chlorine.
   b. 0.75 ppm available chlorine.
   c. 0.5 ppm available chlorine.
   d. 0.4 ppm available chlorine.

4. Why are wading pools more easily contaminated than larger swimming pools?

5. While using the swimming pool, disposable diapers are recommended for use instead of cloth diapers. True or False?
   a. True
   b. False

6. Why is it especially important that drain covers are in place on a wading pool?

GLOSSARY

Acid Demand - The amount of acid required to lower the pH and total alkalinity of pool water to the correct level.

Air Gap - The unobstructed vertical distance through the free atmosphere between the lowest opening from any pipe or faucet supplying water to a tank, plumbing fixture or other device and the flood level rim of the receptacle. (A safe air gap shall be equal to at least twice the inside diameter of the water supply pipe; 2 × diameter.)

Algae - Green or brown microscopic plant life which are nourished by sunlight. Because of their effect on pool sanitation and appearance, their presence is more objectionable than pathogenic.

Algaecide - A chemical that kills algae. An algistat is an agent for preventing their growth.

Alkaline - (Basic) Property of a chemical that neutralizes an acid.

Alkalinity - Represents the content (expressed as ppm $CaCO_3$) of carbonates, bicarbonates, hydroxides, and occasionally borates, silicates and phosphates in water.

Alum - A flocculating agent (aluminum sulphate) used in the treatment of water to form a gelatinous mass in the sand filler. Aids coagulation of suspended solids in water.

Ammonia - Chemical compound composed of nitrogenous wastes, (perspiration, urine) causing chloramines to form in pool water.

Automatic feeders- Electronically controlled equipment for the addition of a chemical into the pool water. Usually for liquid chlorine, bromine and pH feeding into the recirculation system.

Available chlorine - The free or combined chlorine that disinfects pool water.

Backsiphonage - The reverse flow of fluid in a pipe caused by negative pressure in that pipe which draws other fluid into it (i.e. contaminated or non-potable water from a swimming pool or a fixture).

Backwash - To clean a pool filter by reversing or interrupting the normal flow of water through the filters and rinsing the solid matter out of the system to an acceptable location.

Bacteria - Microscopic organisms found in nature, with properties to cause illness and disease. Some types are more harmful to human health than others.

Biocidal agent - A chemical or process for killing all microscopic life (bacteria, protozoa, helminths, algae, viruses, fungi and other undesirable forms) which may be found in swimming pools. Some of these agents are called germicide, bactericide, disinfectant, viricide, fungicide, algaecide, etc., depending on their specific applications.

Body coat - Diatomaceous Earth (D.E.) deposited after precoating a diatomite type filter, resulting from body feed.

Body feed - The continuous addition of controlled amounts of D.E. powder during the operation of a diatomite type filter to maintain a permeable filter cake after precoating. If added as a slurry, this is often referred to as "slurry feed" (see PRECOAT).

Breakpoint - The amount of time when increasing level of chlorine in pool water kills germs and bacteria by oxidizing all organic matter.

Breakpoint chlorination - Application of chlorine based products to water in a sufficient quantity to provide a free chlorine residual, usually 10 ppm of chlorine.

Bridging - Accumulation of filter aid D.E. powder on an adjacent filter element to such a thickness that the clear space between them becomes blocked, resulting from using too much precoat.

British thermal unit (BTU) - One BTU is that quantity of heat which will raise the temperature of one pound of water one degree Fahrenheit.

Brominator - A device (erosion feeder) for dispensing measured amounts of bromine disinfectant into pool water.

Bromine - A dark reddish brown liquid used as disinfectant. Due to instability, it is manufactured as a solid and used in an erosion feeder.

Bromthymol blue - One of the pH indicator solutions, for pH range 6.0 to 7.6. Turns color from yellow to blue as pH increases.

Buffer - A substance in swimming pool water that offers resistance to changes in pH as acids or bases are added to the water.

Calcium hardness - The amount of calcium carbonate (hardness) in the pool water that determines if the water is hard or soft. Normal range for pool water is 200 ppm for balanced water; above 400-600 ppm or under 150 ppm is not considered advisable.

Calcium hypochlorite - Chemical compound of calcium and chlorine used in a granular or tablet form (also called dry chlorine) to disinfectant water; its chemical reaction releases 65 – 70% of its weight as available chlorine.

Cartridge filter - Filtration system that utilizes a fabric or paper filter to remove debris and suspended solids from the pool water. Some filter elements may be disposable.

Chemical feeder - A device to feed a pool treatment chemical at a controllable rate; included are proportioning pumps, injector type feeders, pot-type feeders operating from a pressure differential dry-type feeders, and erosion tablet/stick feeders.

Chlorinator - A chemical feeder used to introduce chlorine into a pool water system. (see HYPOCHLORINATOR).

Chloride - The neutralized or salt form of chlorine that has no significant disinfectant capacity.

Chlorine - A chemical element normally existing as a gas. Chlorine hydrolyzes in the pool water to form hypochlorous acid (HOCl), an active biocidal agent. Extreme care ***must*** be taken when using (see HYPOCHLORITE). Chlorine in the liquid form is usually sodium hypochlorite. Chlorine gas is liquified under pressure and shipped in steel cylinders.

Chlorine, available - The active portion of a product containing chlorine which is available to serve as oxidizing or biocidal agent (usually expressed as per cent by weight). Combined available chlorine is chlorine existing in water in chemical combination with ammonia or organic nitrogen compounds. Free available chlorine is chlorine existing in water as hypochlorous acid and hypochlorite ions (see available chlorine).

Chlorine demand - Amount of chlorine needed to oxidize all organic material in pool water at a given moment or over a period of time. The difference between the amount of chlorine added to water and the amount of residual chlorine remaining at the end of a specified contact period.

Chlorine, liquid - Dry chlorine gas, liquified under pressure, and shipped in steel cylinders.

Chlorine residual - The amount of chlorine remaining in water after chlorine demand has been satisfied (at the end of a specified contact period following chlorination). **Combined chlorine residual** is that portion of the chlorine which has reacted or combined with ammonia and other materials present in a pool water to form chloramines. **Free chlorine residual** is the chlorine concentration that remains available for effective, rapid biocidal action after the chlorine demand has been satisfied. **Free available chlorine** is the more effective germicide and algaecide.

Chlorinated isocyanurate - Chlorine and cyanuric acid compound used to maintain chlorine level in pool water and prevent chlorine from dissipating in sunlight.

Chlorination, free residual - The addition of chlorine to water to produce directly, or through the destruction of ammonia, a free chlorine residual. Also known as "breakpoint chlorination."

Chlorination, super - The development of about a 10ppm free chlorine residual in the pool during non-swimming hours. High chlorine residual will usually kill algae, then be reduced to a satisfactory level within a few hours (also called "Shock Chlorination").

Clarity - Degree of transparency of water essential for bather safety. This lack of turbidity allows viewing the bottom drain covers clearly, while standing on the deck in the shallow end of the pool.

Coagulant - Chemical compound, usually alum, used in pool water to gather and precipitate out suspended matter. (See floc.)

Coliform index - See "Most Probable Number."

Coliform organisms - Bacteria which are found in the intestines of humans and all warm-blooded animals. Large numbers are excreted with the feces of humans and animals. Coliform organisms found in swimming pool water suggest that intestinal pathogens might also be present.

Colorimetric method - A quantitative method used in determining the concentration of a substance in a solution which has a color intensity in proportion to the amount of the substance present.

Combined chlorine residual - Chlorine combined with other substances; sometimes referred to as chloramines. This compound is not as effective as a bacteria killing agent as free chlorine.

Copper sulfate - A poison used to eradicate algae and other microscopic organisms in impounded water and large outdoor swimming pools (also known as "blue vitriol").

Corrosion - The deterioration or destruction of a substance or material by chemical action, frequently induced by electro-chemical processes, the action proceeding inward from the surface; common to metal surfaces.

Corrosion resistant material - A material with exceptional resistance to the corrosion factors to which it is subjected.

Cresol red - A pH indicator solution with a pH range of 7.2 to 8.8 and a color range of yellow to red.

Cross connection - An unprotected connection between a domestic water system and any pool or other non-potable water whereby backflow to the domestic water system could occur.

Cyanuric acid - Chemical used to stabilize or condition pool water by stopping sunlight from dissipating the chlorine residual strength. Not used with bromine.

Diatomite/diatomaceous earth/D.E. - A filter aid consisting of fossilized plankton or the skeletons of marine organisms called diatoms.

D.E. filter - Type of filtration system that utilizes diatomaceous earth as the filter media, when coated upon a fabric grid through which pool water passes, by either pressure or vacuum.

Disinfectant - A chemical that kills or removes the microorganisms which cause infection (pathogenic organisms). Sometimes incorrectly called "sterilizing agent."

Diving area - That area of a pool designed for diving.

DPD - Chemical regent indicators used for testing the free available chlorine/bromine concentration (ppm) of pool water. D.P.D. (Diethyl -p- phenylenediamine) is used to differentiate between free and combined chlorine.

Effluent - The water which "flows out" or discharges from the pool plumbing system, especially that which has undergone a change in the filter or other device.

Electrolysis - Flow of electrical current through acidic liquid or damp earth; corrodes metals.

Equalizer line - A connection with an automatic valve from the pool to the skimmer tank body, sufficiently below the weir and of adequate size to satisfy pump demand and prevent airlock when pool water level drops below weir. The valve opens when the water level drops, allowing pool water to maintain flow, and remains closed during normal skimming.

Erosion feeder - A chemical feed device that holds a solid chemical formulation, which is eroded or dissolved into the pool water by water moving through the feeding device.

Filter - Device for removing suspended particles from pool water.

Filter aid (See D.E., Diatomite type filters) - A finely powdered diatomaceous earth used to coat a septum (grid) type filter. A coagulant, such as alum used in a sand type filter for removing suspended solids.

Filter cycle - The operating time between backwash cycles. Sometimes referred to as "filter run" depending on when a decrease in flow rate occurs due to a dirty filter.

Filter element - The device within a filter tank designed to entrap solids. An element usually consists of a septum support, a grid, and a layer of filtering medium such as diatomite (D.E.).

Filter, sand type - A filter with a layer of filter media (usually silica sand) supported on graded gravel or varied sand materials, through which water flows by gravity or under pressure.

Filter rate - The rate of application of water through a filter during the filter cycle expressed in U.S. gallons per minute per square foot of effective filter area.

Filter septum (grid) - That part of the filter element consisting of cloth, wire screen, or other porous material on which the filter medium or filter aid is deposited.

Floc - Gel-like substance formed when coagulant, usually alum combines with suspended alkaline matter in pool water and precipitates out.

Floor slope - The slope of the pool floor, usually expressed in feet of vertical rise or fall per foot of horizontal distance.

Flow meter gauge - Device used to measure the rate at which water flows through the enclosed piping, measured in gallons per minute (gpm).

Flow rate - Rate at which water travels through the recirculation system, measured in gallons per minute.

Foot spray - A shower head installed at approximately knee height for use by bathers to rinse feet before entering pool.

Galvanic corrosion - Creation of an electrical current by electro-chemical action on two or more dissimilar metals, such as occurs in a storage battery or between copper and iron pipe.

Gutter - Overflow trough at the edge of the pool where pool water is returned to the filtration plant.

Gutter fitting - A drainage fitting used in the overflow gutter (also called "gutter drain").

Hair/Lint strainer - Basket strainer located before the pump which collects hair and other debris from entering the pump.

Hardness - Quantity of dissolved minerals, such as calcium and magnesium, in pool water.

Head - A basic measurement of pressure or resistance in a hydraulic system which is equivalent to the height of a column of water which would cause the same resistance. (100 ft. of head is the equivalent of 43 psi). The "total dynamic head" is the sum of all the resistance in a complete system when in operation. The principal factors of "head" are vertical distance (static head) and resistance due to friction of the flow against the walls of the pipe or vessel. "Friction head" is the head loss due to friction only. "Suction head" is the negative pressure at the suction side of the pump.

Hose bib - A water faucet or wall hydrant to which a hose attaches.

Hypochlorinator - A machine or device for feeding a solution of either calcium or sodium hypochlorite into a recirculating pool water at an adjustable rate.

Hypochlorous acid (HOCl) - An unstable acid capable of disinfecting pool water. This acid is formed when chlorine based products are in the water.

Impeller - The rotating vanes of a centrifugal pump.

Influent - The water from the pool which "flows in" before the pump and filter, especially that which is to undergo a change while in a filter or other device.

Inlet fitting - The fitting through which the filtered water flows into the pool (filtered water inlet), usually adjustable (also called a "return fitting").

Iodine - A chemical element normally existing as a solid. Because iodine is virtually insoluble in water and not added directly to pool water formulations of iodine will be released into pool water for sanitizing (not commonly used).

Lifeguard - An expert adult swimmer certified in lifeguarding and resuscitation, with a valid certificate in lifesaving from the American Red Cross, Young Men's Christian Association (YMCA), or other appropriate agency.

Life ring buoy - A floating ring, having an outside diameter of at least 18 inches, attached to a suitable line at least as long as the maximum width of the pool, similar to or equivalent to U.S. Coast Guard floating ring (also called a "throwing ring buoy").

Main outlet fitting/main drain - The outlet fitting at the bottom of a swimming pool through which water passes to the recirculation pump or to the drain. Usually installed in pairs to reduce the hazard of a swimmer being caught in the "vortex" or suction whirlpool.

Make-up water - Fresh water used to fill or refill the pool through an approved pipe or plumbing device.

ml (or mg/L) - Milligram(s) per liter (see PPM).

Microorganism - A microscopic plant or animal. If disease-causing, it is called a "pathogen."

Most probable number (MPN) - An index of the number of bacteria which, more probably than any other number, would give the results shown by the laboratory examination. It is an estimate based on probability formulas and is not an actual enumeration of the bacteria.

Multiple filter control valve - A special switching valve with a separate position for various filter operations, which combines into one unit the function of several single direct-flow valves (also referred to as a "dial selector valve" or "multi-port valve").

Muriatic acid - Commercial grade hydrochloric acid (HCl), sometimes used to lower the pH or total alkalinity of swimming pool water and to clean masonry surfaces.

Non-potable water - Water which is not safe for drinking, personal, or culinary use.

O.R.P. - The oxidation reduction potential is an effective measure of the oxidizing properties of any sanitizer used in a pool/spa and is measured in milli-watts.

Orthotolidine - Standard reagent for testing chlorine residual.

Overflow gutter (trough) - The gutter around the top perimeter of the pool which is used to skim the surface of the water and used to carry off the waste or to collect it for return to the filters (sometimes referred to as a "scum gutter" or "spit trough").

pH - The measure of acidity and alkalinity of a solution, including water, as indicated by the hydrogen ion concentrations, measured on a scale of 0-14 with 0-7 acidic; 7-14 ppm more basic (alkaline) and 7 being neutral.

Phenol red - pH indicator solution, pH range 6.8 to 8.4. Proprietary grades of phenol red vary in color calibration and correspond only to the test kit employed.

Phenolphthalein - An organic compound used as a color indicator in determing alkalinity.

Pool depth - The vertical distance at a specific point from the pool floor to the water surface.

Pool floor - That portion of the pool interior which is horizontal (or nearly so) or not included in the pool wall.

Pool heater - A water heater designed to warm swimming pool water.

Pool wall - The sides of a pool (above the floor) which are vertical at the top and coved at the bottom, or which are inclined at a slope too steep for walking.

Potable water - Any water supply of approved bacteriological and chemical quality which is safe for drinking.

Potassium Peroxymonosulfate - A nonchlorine oxidizer used in shock treatment of the pool/spa. Chemical does not raise the free available chlorine residual.

ppm - An abbreviation of the term "parts per million" (pounds of substance per million pounds of water, or other equivalent ratio by weight). Used interchangeably with mg/l, i.e. milligrams per liter.

psi - An abbreviation for "pounds per square inch" (see HEAD).

Precipitate - Insoluble compound formed when chlorine or alum added to pool water reacts with other chemicals or minerals.

Precoat - The coating of filter aid on the septum of a D.E. type filter at the beginning of each filter cycle.

Precoat feeder - A device used to automatically feed a measured amount of filter aid at the start of a diatomite type filter cycle, following the cleaning operation (backwash).

Pressure differential - The difference in pressure between two parts of a hydraulic system, such as the influent and effluent of a filter, the suction and discharge of a pump, the upstream and downstream sides of a Venturi tube or an orifice plate.

Quaternary ammonium compounds/QUAT - Soluble cationic compounds which lower the surface tension of water and may also possess algicidal properties. This chemical compound can be used as a sanitizer on shower, toilet, and locker room floors.

Recirculating system - The entire water treatment system including the suction piping, pump, strainer, filter, face piping, return piping, feeders, and instruments.

Return piping - That part of the pool piping from the filter effluent connection to the pool inlet fittings.

Saline waters - Those waters having specific conductance equivalent to a solution of 6,000 ppm of sodium chloride (salt).

Saturation index - A formula based on temperature, calcium hardness, total alkalinity and pH that, when calculated, will determine if the pool water is corrosive, neutral, or scale-forming.

Scale - Hard deposit of minerals on heater coils and pool surfaces.

Seal of approval - Evidence of current approval status with the National Sanitation Foundation Testing Laboratory, Inc., such as a decal or imprint bearing the NSF seal.

Service factor (Motors) - A factor indicating the degree to which an electric motor can be operated over a specific rated horsepower without danger of overload failure.

Shepherd's crook - A rescue pole, capable of being extended to all parts of the pool bottom, constructed usually of bamboo and having a metal hook at the end with an opening of at least 18 inches between the tip of the hood and the end of the pole.

Skimmer - Device that continuously draws surface water and debris from the pool into the filtration system.

Soda ash - (Sodium carbonate ($Na2CO_3$)) A dry chemical used to increase pH and total alkalinity in pool water.

Sodium bicarbonate ($NaHCO_3$) - Chemical compound used to increase total alkalinity. Does not significantly change the pH of the pool.

Sodium bisulfate - A dry acid ($NaHSO_4$) that, when mixed with water, lowers pH and total alkalinety of pool water (also called "pH reducer").

Sodium hypochlorite - A liquid chemical that provides 12% to 15% available chlorine for disinfection of the pool water. Produces hypochlorous acid when added to pool water.

Sodium thiosulfate - A chemical used to neutralize the chlorine or bromine in the water of a swimming pool sample that is to be tested for bacteria or pH.

Spineboard - An instrument used to immobilize a person who has incurred an injury to the spine or other vital body part and requires immobilization. It is constructed of flat, rigid, buoyant material, about 18 inches wide and 6 feet long, with handholds for transportation purposes, tie down straps and support runners underneath the board.

Standard Methods - The publication entitled "Standard Methods for the Examination of Water and Wastewater," prepared and published jointly by the American Public Health Association, the American Water Works Association, and the Water Pollution Control Federation, containing methods for the examination of water, wastewater, and other materials related to sanitary investigations.

Standard plate count - A technique for determining the bacterial density of water, based on an approximation of the total number of bacteria that grow under specified laboratory conditions. It also is referred to as the "bacteria count," the "total bacterial count," and the "agar plate count."

Sterilize - To kill all microorganisms by heat or chemicals. Not be confused with "disinfect."

Suction piping - That part of the pool piping between the pool and suction side of the pump—usually consisting of piping from the main outlet, vacuum cleaner fittings, overflow gutters or surface skimmers—to the pump strainer and pump.

Superchlorination - Heavy dose of chlorine added to pool water to burn out nitrogen compounds when bacteria, algae, or ammonia build-up cannot be reduced by normal treatment.

Surface skimmer - A device, usually built into the pool wall, consisting of a floating or adjustable weir over which water flows from the pool surface into a small housing or tank; the pump suction then draws it to the filtration equipment. Basic components are the housing, strainer basket, weir, ring and cover, equalizer valve (air-lock protection) trimmer valve (to adjust flow between skimmers), and pipe connections to pump suction, equalizer line, and, sometimes, the vacuum cleaner.

Swimmer load/bather load - The maximum number of persons allowed inside the pool enclosure, including those on the deck who are potential swimmers.

Total alkalinity - Total amount of carbonates, bicarbonates and hydroxides in pool water which helps buffer and control pH. Level should be 80-125 ppm depending on the type of sanitizer used.

Total dissolved solids (TDS) - The measurement of all materials dissolved in water, i.e. calcium, carbonates, dissolved organic and inorganic materials, salts from chlorine residue, swimmer waste, soluble hair and body lotions, or anything placed in water that can be dissolved.

Turbidity - Degree to which pool water is clouded by suspended matter. Color may or may not be present. (Might be defined as "lack of clarity.")

Turnover - The period of time required to circulate a volume of water through the filter system that is equal to the pool capacity. Usually measured in hours; i.e. 6 hour turnover rate.

Underdrain - The distribution system at the bottom of a sand-type filter that collects the filtered water during the filter cycle and distributes the backwash water during the cleaning operation.

Underwater light - A fixture designed to illuminate a pool from beneath the water surface. Wet Niche Light: A watertight and water cooled unit submerged and placed in a niche in the pool wall, accessible only from the pool. Dry Niche Light: A weatherproof fixture placed behind a watertight window in the pool wall, accessible from the deck or a pipe tunnel.

Vacuum breaker - A mechanical device which is installed to prevent backsiphonage of non-potable water into the potable water supply. Usually installed at the hose bib.

Vacuum cleaner fitting - A hose fitting connected to the suction piping, usually in the wall of the pool just below the water level, to which is attached the hose for the underwater vacuum cleaner.

Velocity - Rate of movement of water measured in feet per second.

Wall slope - The inclination from vertical in a pool wall expressed in degrees or in feet (or inches) or horizontal distance in a given depth in feet (or inches).

Weir assembly, skimming - The floating device and its means of guiding or attachment within the surface skimmer over which the surface water from the pool passes during the skimming operation.

Answers to Review Questions

Chapter 1

1. e.
2. pH, Organic matter, Total alkalinity, Calcium hardness, Temperature, Disinfectant levels, Total dis solved solids
3. a.
4. d.
5. The pool's design and construction, filtration equipment, and multiple inlets with adequate recirculation flow help to maintain clean water.
6. a.
7. The D.P.D. (diethyl-p-phenylenediamine).

Chapter 2

1. From swimmers, rain, dust, dirt, and organic materials such as leaves, grass, etc.
2. a. True
3. Gastrointestinal tract, skin, eyes, ears, nose, throat and skin.
4. Presence of organic matter for food; pH levels out of desirable range; high temperatures; inadequate amount of chlorine residual; salinity and debris in the water; ambient light.
5. 1) folliculitis and dermatites (skin)
   2) conjunctivitis (eyes)
   3) pneumonia (lung)
   4) otitis externa and otitis media (ears)
   5) forms of legionnaires disease
6. Gives the pool water a turbid and dirty appearance; Causes bathers to itch; Causes the surfaces around and in the pool to become slippery and unsafe; Increases chlorine demand; Absorbs pesticides and reduces treatment effectiveness; Gives the pool water a disagreeable odor or taste; Clogs water-filtering systems.
7. Properly designed swimming pools can greatly reduce the potential of algae growth. Providing suitable water disinfection residual and proper filtration equipment, multiple inlets with adequate recirculation flow, and smooth pool surfaces are important for reducing algae. For outdoor pools, the likelihood of algae may be reduced by shading the water from the sun.
8. b. False
9. 1. salmonellae; 2. shigellae; 3. compylobacter; 4. giardia
10. Decks, toilets, locker room facilities, bathers, and personal items.
11. b.
12. a.
13. b.
14. b. False

Chapter 3

1. E, D, B, C, A
2. a. Chain or secure gas cylinders to prevent tipping.

   b. Store cylinders in a fire resistant room with adequate ventilation capable of complete air exchange in 1 to 4 minutes.

   c. Place a new lead gasket on the regulator whenever the cylinder is changed.

   d. Locate safety equipment (gas mask) outside the storage room at all times.

   e. Store gas cylinders separate from other chemicals and equipment.
3. Cyanuric acid remains fairly stable in the pool water while dissolving slowly. It releases chlorine into the pool water as it dissolves leaving more chlorine in the water.
4. The pH will be lower since bromine has a pH of 4.0 – 4.5. Soda ash will need to be added to the pool to raise the pH.
5. a. UV ultraviolet light
   b. Corona discharge mechanisms
6. The pH reading is a measure of hydrogen ion (H+) concentrations. The pH scale ranges from 1-14, with 7 being neutral. Anything with a numerical value less than 7 is said to be acidic and a numerical value greater than 7 is considered alkaline.
7. Low pH causes corrosion of equipment and surfaces.
   High pH is scale forming; chlorine is less effective as a sanitizer; and water becomes irritating to the eyes and skin.
8. Impermeable gloves and safety glasses must be worn to protect the eyes and skin from the chemical. Use an automatic dispenser or when dispensing

acid directly into the pool pour it slowly next to the water's surface to prevent splashing and pour it into the deepest part of the pool.

9. Cyanuric acid level is too high. Drain the pool to eliminate this excessive concentration of cyanuric acid.

Chapter 4

1. c.
2. The OTO test is used to measure total chlorine while the D.P.D. test measures free available chlorine, required by MDEQ.
3. Pull the sample 12" below the water.
   Add reagent #1 or tablet to measured amount of water.
   Add reagent #2 if necessary.
   Compare results with color chart or equivalent.
4. Touching the reagent tablets or the dispensing tips of the reagent bottles can contaminate the water. Using the finger as a stopper on top of the viewing tube could allow body oils to enter the sample.
5. When the addition of the reagent changes the color to "clear", it indicates an excessive amount of chlorine or bromine in the pool. Before adding the reagent, dilute a new sample with a known amount of tap or distilled water. Multiply the result by the appropriate factor. For a 1-1 dilution multiply by two, for a 1-2 dilution, multiply by 3, etc.
6. d.
7. d.
8. 21 drops x 10 = 210 ppm for total alkalinity, which indicates a high total alkalinity (80-120 ppm is recommended).
9. No. Test kits with reagents must be used.

Chapter 5

1. d.
2. The coliform bacteria group are intestinal bacteria. They are relatively weasy to use in a lab setting and are indicators of possible fecal contamination or presence of other pathogenic microorganisms.
3. Michigan's rules require one bacterial sample per week. The public health officer may increase or decrease the sampling frequency based on past inspections and water quality.
4. c.
5. a. Hold the sterilized bottle near the water's surface.
   b. Remove the cap and avoid touching the sterile bottle neck.
   c. Plunge the bottle downward in the water 12"-18" deep and bring upward in a sweeping motion to the surface.
   d. Without touching the bottle neck and rim, make sure it is full to the neck, then cap.
   e. Deliver or mail the sample to a certified laboratory in your area for analysis.
6. The "membrane filter" method is recommended for coliform group testing while the "Most Probable Number" (M.P.N.) test is used for standard plate count
7. Consider the time of sampling, water quality and clarity, disinfection level and bather loading.
8. a. The age of the sample at the time of analysis (time sample was collected).
   b. How and where the sample was taken.
   c. Limitations of the test procedures and laboratory analysis.
9. Best location is near swimmers in the pool. Poor location is by an inlet where chlorinated water enters.

Chapter 6

1. It is a formula for calculating if the pool water is in chemical balance or equilibrium by determining if the water is either corrosive or scale forming.
2. pH, as measured from the test kit; TF, temperature factor, measured at the pool; CF, calcium hardness, measured from kit; AF, alkalinity factor, measured at pool from kit.
3. Langelier Saturation Index = pH + TF + CF + AF – 12.1
   7.2 + (0.6 for 76°) + (2.1 for 300 ppm CF) + (1.9 for 75 ppm T.A.)- 12.1
   7.2 + 0.6 + 2.1 + 1.9 – 12.1 = 0.3
   Pool is within tolerance of 0.5± for balanced water.
4. **Low pH:** 1. Red eyes, 2. Hair loss, breaks off, 3. Pool surfaces deteriorate, 4. Staining, 5. Cloudy water.
   High pH: 1. Forms scale, 2. Chlorine is ineffective 3. Plugged filtration, 4. Irritation to users (skin, eyes), 5. Cloudy water
5. While wearing protective clothing, pour the full-strength muriatic acid into the water at the deepest part of the pool, in a circular area about 18 inches in diameter.
6. c. 50,000 gallons divided by 10,000 = 5
   1 quart x 5 = 5 quarts of muriatic acid for 50,000 gallons of water
7. c.
8. b. If above or between 400-600 ppm it is very scale forming.
9. a.

Chapter 7

1. c.
2. Combined available chlorine (C.A.C.) is the combination of chlorine and contaminates and is called chloramines.

   Total available chlorine is the sum of both the chloramines and free available chlorine.
3. a.
4. Referred to as "shock treatment", super chlorination is performed to control algae or whenever the combined chlorine level exceeds 0.2 ppm. Super-chlorination requires the addition of 10 times the combined chlorine residual. Super-chlorination helps burn-up organic debris, such as algae, in the pool water that normal chlorine residuals can not control.
5. $\frac{\text{Pool volume} \times 8.3 \times \text{C.A.C.} \times 1.0 \times 10}{1{,}000{,}000}$
6. 0.8 ppm combined available chlorine.
7. $\frac{120{,}000 \times 8.3 \times 0.8 \times 1.0 \times 10}{1{,}000{,}000} = 7.9$
8. Yes. There is no increase of chlorine residual in the pool, so it will not harm the swimmers.
9. Trichloro-isocyanurate.

Chapter 8

1. Pool volume = length x width × average depth × 7.48

   $(50' \times 25' \times \frac{3+7}{2}\ [5] \times 7.48 = 46{,}750 \text{ gallons})$
2. The water flows into the pool skimmer and drains to the *hair and lint strainer,* then to the pump, where the water is under pressure. The pump forces the water to the *filter(s),* heater if required, and is returned to the pool through *inlets* in the walls. The *chemical feeder* for disinfection is attached to the system.
3. $\text{Flow rate} = \frac{\text{volume}}{\text{hours \& minutes}}$

   $$\frac{40{,}000}{6 \text{ hours} \times 60 \text{ min./hr.}} = \frac{40{,}000}{360} = 111 \text{ gpm}$$

   $$\frac{40{,}000}{8 \text{ hours} \times 60 \text{ min./hr.}} = \frac{40{,}000}{480} = 83 \text{ gpm}$$
4. For a high rate sand filter, the range is 12-20 gpm/square ft. of filter area. Yes, there is an ideal filter flow rate of 15 gpm.
5. $$\frac{\text{Pool volume in gallons}}{\text{turnover rate (60 min/hr)}} = \frac{36{,}000 \text{ (gallons)}}{6 \text{ hrs} \times 60 \text{ min/hr}} = \frac{36{,}000}{360} = 100 \text{ gpm}$$

   $$\frac{\text{Flow rate}}{\text{Filter flow rate/sq. ft.}} = \frac{100 \text{ gpm}}{2.0 \text{ (D.E. filter sizing)/sq. ft.}} = 50 \text{ square feet of filter area}$$
6. 1. When the incoming (influent) pressure is 10-12 psi greater than the clean filter pressure.

   2. When the flow rate decreases from resistance in a dirty filter.

   3. When the pool water becomes cloudy with debris still in the water.
7. No. This is not recommended as a routine filtration enhancement since it is considered a temporary measure. The filter aid may clog the filter and causing an increase in operating pressure.
8. No. Due to lack of efficiency and space required for such a large open tank, they are usually replaced with high rate sand filters.
9. **Rectangle:** Multiply the length (L) by the width (W).

   Circle: 3.14 × radius (one-half the diameter) times the radius.

   Area = 3.14 × radius × radius.

Triangle: Multiply the width at the base (W) by the height (H), and divide by 2.

$$\textbf{Area} = \frac{W \times H}{2}$$

10. There are a couple of ways to calculate the area of and irregularly shaped pool:
    1. Reduce the site to a combination of rectangles, circles and triangles. Calculate the area of each and add them together to obtain the total area.
    2. Establish a line down the middle of the site for the length, and then measure from side to side at several points along this line. Use the average of the side measurements as the width. Then calculate the area as a rectangle.
11. Multiply the depth by the area of the circle at the base.

    Volume = Depth × 3.14 × radius × radius

Chapter 9

1. a. Compact, no backwashing required

   b. More effective filtration in a small system

   c. Less maintenance, longer filter runs
2. d.
3. a. Remove dirt and debris with a hose, a spray nozzle and clean water.

   b. Submerge the element and soak in soap solution (automatic dishwasher detergent mixed with 5 gallons of water).

   c. While wearing PPE, after rinsing the element, place it in a solution of 4 cups muriatic acid and 5 gallons of water. Soak for ±4 hours. Rinse with soda ash solution.

   d. Rinse with clean, clear water and replace into filter housing.
4. The higher water temperature causes body oils to be released at a faster rate and to accumulate on the filter, requiring more frequent cleaning.
5. The D.E. powder forms a coating on the filter grid that traps smaller suspended solids than a sand filter. The "filter cake" allows water to pass through, but not the dirt.
6. A 75 sq. ft. filter needs 75 sq. ft. × 0.125 lbs. = 9.37 lb.

   or

   sq. ft. × 2 oz./sq.ft. = 150 oz. divided by 16 oz./lb. = 9.4 lbs.
7. b.
8. The pump could be damaged if not turned off when switching modes.
9. a. A heavy dirt load from debris or extra bathers in the pool that did not shower.

   b. Incorrect quantity or grade of D.E. powder on the filter.

   c. Dirty filter grids clogged by grease, algae, slime or suntan lotion.

   d. Inadequate backwashing, resulting in particles of old D.E. powder remaining in place.

   e. Damaged gaskets, elements or grids that would allow dirt to pass through.

   f. Compacted D.E. powder from improper or excessive flow rate.

   g. Calcium deposits on the filter elements reducing available area for filtering.
10. a. Wrong grade of D.E. powder-- Use only the type recommended by the manufacturer and use in correct amounts.

    b. Damaged filter elements-- Repair or replace any element or grids when tears or rips appear.

    c. Calcium deposits on elements-- Disassemble filter and thoroughly clean all elements of deposits before re-assembly.

    d. Compacted D.E. powder from improper flow rate— Keep the recirculation flow rate at the optimum rate, not too high or too low.

Chapter 10

1. b.
2. d.
3. d.
4. Children have more bowel and bladder accidents than adults.
5. b.
6. If the covers are not secured in place, children could sit on them and have body parts, or hair sucked, into the drains from recirculation pressure.

APPENDIX A
Opening and Winterizing Pools

LEARNING OBJECTIVES

After studying this material completely, you should be able to:

- Properly open a pool at the beginning of the season.
- Properly close a pool at the end of the season.
- Describe and list the winterizing actions for an outdoor swimming pool.
- Compare winterizing procedures for drained vs. undrained pools.
- List and understand sand filter, D.E. filter and skimmer winterizing techniques.
- Understand why equipment needs to be winterized against damage.
- Discuss why preventive maintenance is economical for the pool operation.

Opening Swimming Pools for the Season

To open a pool properly at the beginning of the season, use the following guidelines. This opening checklist is designed to assist the operator in the efficient and speedy opening of the pool. This list is *not all inclusive* but addresses important areas of concern.

1. After removing the cover, remove all leaves and debris from the water. Clean gutters and skimmers and ensure proper functioning: clean main drain, confirm the main drain is functioning and secure the drain covers. Clean all interior surfaces of the pool and deck thoroughly.
2. If there was no physical cover on the pool, or excessive dirt and debris entered the water, you may need to drain the pool and mechanically remove the solids. The filters may not remove all the debris efficiently.
3. Check the hydrostatic relief valve in the main drain—rocks and other debris could cause the drain to remain open.
4. Check for frost damage and cracks in the pool structure, coping, deck and surrounding areas. Repair damage and roughened areas that could allow algae growth or cause accidents.
5. Repaint the pool surfaces, including the depth markers and "NO DIVING" signs if necessary. Remember to use compatible paints. All coping and deck lettering must be visible. "NO DIVING" must be prominently displayed on the deck surface in water less than 5 feet deep.
6. Close all drain lines and begin filling the pool. Flush to waste any anti-freeze from the lines, and never allow the chlorine to come into contact with it. Use biodegradable anti-freeze if the discharge is not captured and disposed of in a hazardous waste collection.
7. Finish filling the pool with water to the operational level.
8. Start the motor and begin filtering the water. Be sure that 80% of the flow back to the filters comes from the surface skimmers and 20% from the bottom drain. Confirm that pump and filter(s) are working properly. Remove the top of the filter to check the condition of filtering media. Sand or D.E. filter elements may need cleaning or acid washing before being placed into operation. D.E. filter powder should have stored well through the winter, but the sand in the filter may need replacing if it has "channeled" or migrated. Confirm that all gauges, thermometers, and flow meters are properly working and providing correct readings. Confirm that all water inlets are covered with adjustable covers, if specified by design, and that they are properly discharging water returned from the pool filter into the pool in a counterclockwise direction. Have replacement parts available if repair to the pump, motor, or distribution mechanism of the disinfecting device is needed.
9. Once the pool is filled, the water may then be sanitized, but be sure to clean the chlorinator or brominator before use. Bring the chlorine residual to at least 5.0 ppm, or bromine level to 10 ppm. This helps burn off any debris left in the pool water.
10. Continue the pump and filter operation until the water is clear and free of debris.
11. Begin chemical balancing of the water for disinfectant residual, pH, alkalinity, total hardness, dissolved solids and mineral content (if needed). Stabilize:
    - chlorine residuals at 1.0 to 1.5 ppm.
    - pH at 7.2 to 7.6 (ideal range).
    - total alkalinity between 80-120 ppm.
    - calcium hardness in the range of 200 ppm.
    - total dissolved solids below 1,500 ppm.
12. Establish the water sampling and testing schedule and keep records of the results and action taken to balance the water parameters. Test kit reagents must be matched for the same type and manufacture of test kit and replaced at least yearly, if a seasonal pool, or every six months. Have sample bottles for bacteriological analysis of water accompanied with the correct forms available before opening the pool.

13. Display all signs so they are easily seen and read by swimmers. Include pool rules, caution signs, occupancy bather loading, and the warning of "no lifeguard on duty," if applicable. Spa pools must post "caution" signs regarding use of the pool.
14. Fencing around the pool enclosure must be in good repair with the gate(s) self-closing and capable of being locked, if needed. All areas of the fence must keep people from climbing over or under the fence or gate.
15. The vacuum cleaning hose system must be in good repair. Check for holes in the hose and replace, if necessary. Should the vacuum cleaning system be connected to the skimmer system, the suction from the pump must be acceptable. If not, the skimmer lines may need to be "blown out" with water under pressure or with compressed air.
16. Install the lifeline across the deep and shallow ends to separate the two areas. Keep the rope and buoys across the pool, secured to each side of the pool. Secure ladders and handrails to the deck. Confirm that they are in good repair and accessible for public use.
17. Check safety equipment for "sun rot" and wear; replace as needed. Locate safety equipment where the public can easily reach it, if necessary.
18. Chemical containers must be properly labeled, stored in a clean, dry environment with adequate ventilation and with instructions available on how to use the various chemicals.
19. There must be an emergency telephone accessible at all times for public use. Make sure the phone is operational. Along with the accessible telephone, post the location and phone number where the maintenance staff can be reached and available to respond within 15 minutes.
20. Turn on the foot-spray by the entry gates. Repair if leaking. Turn on and repair the drinking fountain if needed. Check the attached hose bibs and vacuum breakers on the faucets to determine if they are functioning. If not, contact a plumber for repair or replacement.
21. When the pool operator feels confident about the condition and operation of the pool, contact the local health department for an opening inspection. MDEQ requires this inspection prior to opening.

Winterizing Swimming Pools

Proper winterizing and winter care of a pool prevents the possibility of freezing damage to equipment or piping. The following procedures should be the minimum procedures for preparing a pool for the off season.

There are several schools of thought regarding draining a pool or leaving it filled during the winter. Pool tanks of poured concrete have been destroyed by frost heave when completely drained. Do not drain the pool completely when any of the following conditions exist:

1. A pool built in an area where the groundwater level might rise above the bottom of the pool. This is particularly important if the pool is not equipped with a hydrostatic relief valve. In colder climates, the moisture in the ground freezes, causing pressure on top of the pool. This results in "buckling" of the structure.
2. Do not drain a pool with an interior finish of plaster or tile. Areas where the tile or plaster are not bonded to the pool structure will be damaged by freezing conditions.
3. Do not drain a pool with walls of questionable or unknown structural strength.

Winterizing Procedures for Drained Pools

1. Open drain valve, allow all of the water to drain from the pool, and leave the valve open. If gravity drainage is not available, pump the water from the pool to an approved drainage area. Check with the local municipality or Department of Public Works for options on pool drainage locations. Most self-priming pool pumps will lift the water eight feet or more. However, they will not pick up a prime for more than four feet. Therefore, once you start pumping a pool out, run the pump continuously until the pool is empty. Use non-toxic anti-freeze protection fluids to winterize the system.
2. If a hydrostatic relief valve is installed in the main drain sump, confirm that it operates. Keep a cover on the bottom drain to prevent rocks and other debris from entering it during the winter.
3. Remove leaves and other debris to prevent staining.

Winterizing Pools Left Filled for Winter

1. Pump or drain the water level down below the inlet fitting of the pool and allow all pool lines to drain into the pool.
2. Put a cover over the pool to help prevent debris from accumulating in the pool water.

Winterizing Sand Filters

1. Remove the top of the filter or manhole cover to examine the filter sand.
2. If the sand surface is not too dirty or crusted, dig down into the sand and determine its state of cleanliness through the profile.
3. The sand should not be channeled or cemented together, and should not contain mud balls or calcified chunks. Treat with a filter-cleaning compound used in accordance with the manufacturer's recommendations, or change before reuse.
4. Turn on the pump and backwash filter to waste, as approved by the local municipality which may include sewer, storm drain, or other approved area.
5. Remove plug from bottom of tank and allow water to drain out of the tank when done backwashing.
6. Open all valves on filter system and leave them open.

Winterizing Diatomaceous Earth Filters

1. Remove the tank cover and take filter elements out of the tank.
2. Clean elements to remove accumulated soils and other deposits in accordance with the manufacturer's recommendations.
3. Place elements loosely in the tank.
4. Remove plug from the bottom of the tank and allow all the water to drain out of the tank and leave open.
5. Open all valves on the filter system.

Winterizing Pumps

1. Turn off the pump switch and open the circuit breaker to the pump circuit.
2. Remove the lid and basket from the pump strainer; clean the basket and set aside.
3. Remove the drain plugs from the strainer pot and pump.
4. Remove the impeller from the motor to examine for possible damage or to see if it needs replacing. Lubricate all parts, and cover for the winter.

Winterizing Chlorinators and Other Chemical Feeding Equipment

1. Drain water from all parts and lines. Make sure there is no disinfectant chemical left in the system that could corrode the pipes, lines, or equipment.
2. If equipment is installed outdoors, remove and store inside.
3. Disassemble and clean.

Winterizing Pool Lights

1. Drained Pools
   a. Examine all lights for signs of leakage.
   b. Where leakage has occurred, remove light from niche, disassemble, dry out, replace defective gaskets, and reassemble.
   c. Replace light in niche.
2. Pools Left Filled with Water
   a. Remove lights from niches and place on pool deck.
   b. Examine lights for signs of leaks and wherever leakage has occurred, follow procedures described.
   c. Store light on pool deck, under a wooden cover or equivalent.

Winterizing Skimmers

1. Drain and cover all skimmers to prevent entry of snow, rain, rocks and other debris.
2. If skimmer drainage is impossible, a semi-inflated bicycle tube should be stuffed into the skimmer to absorb pressures created by freezing and thawing. Commercial "plugs" are available from pool service companies.
3. Remove the plastic floating weir and store in a dry place.

Winterizing Heaters

1. Turn off the fuel supply to the heater.
2. Drain water from the heater according to the manufacturer's instructions.

Winterizing Recirculation Systems and Pool Piping

1. Open all valves in pool piping.
2. Shut off water to fill spout, and drain this line.
3. Open any special drain plugs in the pool piping.
4. Remove the vacuum plug and allow the line to drain.
5. Be sure there are no low points in your pool piping system to collect water and freeze. If necessary, loosen unions to help drainage.
6. If available, use compressed air to clear lines.
7. All piping, whether metal or plastic, should be completely cleared of all water.

Winterizing Deck Equipment

1. Remove the diving board and store it inside, in a flat position.
2. Remove and store ladders, if possible.
3. Remove bolts and wedges from deck anchors.

Winter Chemical Storage

1. Water treatment chemicals should be stored in a ventilated, cool, dry place, protected from freezing.
2. The polyethylene bag inside a drum of calcium hypochlorite should be twisted tight, and the lid secured. This will preserve the material.
3. Store water test kits and reagent chemicals where they will not freeze.
4. Return any extra supply of sodium hypochlorite solution to the dealer. This material loses strength in storage. Avoid having excess chemicals by purchasing only what you need for operations during the season.

Preventive Maintenance

1. Make any repairs needed to gauges, flow meter, valves, test kits, or other equipment so they will be ready to place back into service next spring. Order any necessary parts from the manufacturer. Store all removed plugs, caps, covers, and other loose parts in a secured cabinet.
2. Paint all exposed iron or steel with rust-preventive paint.
3. Lubricate all moving parts according to manufacturer's standards.

APPENDIX B
Troubleshooting for Pool Operations

AREA OF CONCERN: PUMP

Problem: **Pump doesn't run**

Likely cause: **Blown fuse, wrong size, or low voltage:**
Replace fuse; use proper fuse and wire size; may need to contact power company.

Loose or broken wire:
Replace defective wiring; look for heat stressed wires; tighten all connections.

Defective motor:
Repair or replace motor (call a qualified service technician).

Problem: **Pump runs- no water**

Likely cause: **Air pockets, leaks in suction line:**
Properly prime pump; check for leaks in suction side plumbing.

Pool water level below skimmer:
Raise water level- must be above bottom of skimmer opening.

Valve closed:
Check suction side valves, they must be open.

Too high suction lift:
Elevation of pump is above water level in excess of manufacturer's recommendations.

Incorrect line voltage:
Use a voltmeter to check wire size; if size is correct you need to contact the power company.

Problem: **Pump starts, then stops**

Likely cause: **Motor improperly wired:**
Return for service.

Clogged filter:
Backwash and clean filter.

Closed or partially closed valve:
Check valve position; may need to replace valve.

Problem: **Pump runs; water in basket moves slow with reduced pumping capacity**

Likely cause: **Air pockets; leaks in suction lines:**
Check for leaks in suction side lines.

Bent shaft; misalignment of shaft:
Replace shaft.

Damaged motor/pump (e.g. bearings, shaft):
Return for service.

Clogged hair strainer:
Clean or change basket.

Clogged pump impeller:
Clean pump parts.

Valve closed:
Check suction and pressure side.

Problem: **Pump loses prime**

Likely cause: **Air leaks in suction side:**
Check for leaks with soap/water (e.g. strainer basket, suction side pipe connections).

Excessive air carried to pump from pool:
Water level may be too low for skimming from a break in suction side plumbing.

AREA OF CONCERN: MECHANICAL

Problem: **Valves hard to turn**

Likely cause: **Dry valve stems:**
Lubricate valve stems or replace.

Problem: **Water leaks; valves**

Likely cause: **Water leaks from loose packing at valve stem:**
Tighten or replace packing and nuts.

Problem: **Water leaks; pump**

Likely cause: **Loose packing and fittings:**
Tighten packing and replace if over tightening doesn't work.

AREA OF CONCERN: ELECTRICAL

Problem: **Power shortage**

Likely cause: **Breaker connection continues to switch to off position; lights kim, equipment slows down:**
Check with power company and service technician. Check voltage and short circuiting.

Problem: **Sparks, smoke**

Likely cause: **Faulty equipment.**
Turn off power immediately; call a qualified service technician.

AREA OF CONCERN: FILTERS - DIATOMACEOUS EARTH (D.E.)

Problem: **Short filter runs**

Likely cause: **Too much earth (D.E.) used or D.E. caked up on grids:**
Backwash and recharge with amount specified by manufacturer.

Problem: **D.E. powder found in pool**

Likely cause: **Filter grids damaged, out of proper position:**
Repair or replace grids and check for cracks.

Problem: **Loss of D.E. powder on filter grids:**

Likely cause: **System shut down for too long and D.E. powder falls off:**
Only shut off filter for short "BUMP" of excess D.E. powder to waste.

AREA OF CONCERN: FILTERS - HIGH RATE SAND

Problem: **Short filter runs**

Likely cause: **Floc has entered pool:**
Adjust alum feeding.

Excess debris in pool:
Screen off floating particles and vacuum settled material.

Scale-forming water:
Test all parameters and use Langelier Saturation Index to balance water chemistry.

AREA OF CONCERN: FILTERS - CANISTER/CARTRIDGE

Problem: **Float stuck**

Likely cause: **Dirt and debris in tube:**
Remove and thoroughly clean; replace if necessary.

Problem: **Reading too low**

Likely cause: **Improper flow rate:**
Check turnover rate with vacuum gauge and pump curve.

AREA OF CONCERN: FLOW METER

Problem: **Top leaks**

Likely cause: **Worn threads on top of meter:**
Replace top or use teflon plumbing tape to stop leaks.

Problem: **Float sticks**

Likely cause: **Dirty parts:**
Remove and clean.

AREA OF CONCERN: PRESSURE GUAGES

Problem: **Pressure gauge reads too high**

Likely cause: **Improperly calibrated gauges:**
Replace with 0-60 psi gauge, calibrated in 2 degree increments.

Problem: **Pressure readings different**

Likely cause: **Gauges not at same elevation:**
Mount both filter influent and effluent gauges at the same elevation.

Gauge orifice clogged between pipe and gauge:
Flush orifice or replace gauge.

Continued on next page

AREA OF CONCERN: CHEMICAL FEEDERS HYPOCHLORINATOR OR pH FEEDERS

Problem: **Clogged lines**

Likely cause: **Chemical deposits (i.e. $CaCO_3$-hardness):**
Recommend flushing line with vinegar (weak acid) solution. Check for suction line resting on bottom of tank; if so, move it.

Problem: **No chemical in line**

Likely cause: **Air pockets in suction line:**
Prime suction line. Check all suction line tubing for cracks or splits.

Line pressure exceeds chemical pump capacity:
Change injection point from downstream from pump to upstream from pump. Install anti-siphonage valve on discharge line.

Problem: **Lack of power to meter, feeder or alarm**

Likely cause: **Blown fuse or bad connection to unit:**
Change fuses, service chemical feeder, replace.

Problem: **pH meter not registering:**

Likely cause: **Bad electrode, meter, or no flow by electrode:**
pH of water over 8.0 or under 6.0 will not properly register. Adjust pH; clean or replace electrodes.

Do a manual check with test kit to make sure chemicals are within desirable range.

Problem: **Chlorine meter not registering:**

Likely cause: **Bad electrode, pH too high or low, chlorine too high or low:**
Adjust water quality, replace electrodes or meters, check for air in chemical lines(s).

Do a manual check with test kit to make sure chemicals are within desirable range.

Problem: **Over-application of chemicals**

Likely Cause: **Injection fitting not properly placed:**
Relocate injector to suction side of pump instead of discharge side.

Chemical solution too high in storage tanks; must be diluted.

Recalibrate system.

Problem: **Cannot maintain proper levels of pH or chlorine solution**

Likely cause: **Solution too strong or too weak; chemical feeder not working:**
Adjust amount of chemical in storage tanks.

Check equipment for problems.

Improper position of suction hose in tank:
If hose is near top, it will draw air rather than liquid.

Suspend end of line near bottom of tank.

Clean hose and filter with weak acid or vinegar.

Diaphragm in pump ruptured or broken:
Replace internal parts of pump (i.e. diaphragm or hose).

AREA OF CONCERN: WATER QUALITY

Problem: **Cloudy water**

Likely cause: **Hand feeding of D.E., soda ash or chlorine in powder causing precipitation of hardness compounds:**
Feed chemicals ahead of the filter in the correct manner. Place powdered chemicals in solution before adding to the pool.

Reduced flow rate:
Backwash filters.

Additional bather loading:
Superchlorinate pool.

Limit use of pool to designated number of bathers.

Need for chemical adjustments:
Check reagents in test kit for accurate readings.

Adjust water quality.

Filter media dirty:
Clean or change filter media (sand; D.E. or canister)

Problem: **Dull colored water**

Likely cause: **Heavy dirt load in the filters:**
Superchlorinate to 10 ppm.

High TDS:
Remove some water and replace with fresh source.

Poor water balance:
Manually test all water parameters and use the Langelier Saturation Inex to identify water problems.

Problem: **Green to reddish brown colored water**

Likely cause: **Algae and minerals in the water:**
Check water quality for iron, copper, manganese, or algae growth.

Adjust water quality with algicide or sequestering agents.

Adjust water balance if corrosive.

Problem: **Foamy water**

Likely cause: **Detergent in pool:**
Change the water.

Water hardness too low:
Adjust calcium hardness; add a defoamer.

Problem: **Air bubbles**

Likely cause: **Leak on suction line of pump:**
Check for leaks on suction side of pump; bleed out water in filter.

AREA OF CONCERN: HYDRAULICS

Problem: **Loss of water in pool**

Likely cause: **Leaking lines and fittings:**
Check bottom drain hydrostatic relief valve for blockage.

Broken pipes:
Check inlets and outlets with food coloring.

May need professional "sounding" of pool for broken lines.

Problem: **Pool floats or moves, cracks**

Likely cause: **High water table in area under pool:**
DO NOT drain pool when water table is so high; replace hydrostatic valve.

Problem: **Howling sound from pump**

Likely cause: **Pump cavitation:**
Check for blockage on suction side (skimmer, drain); increase discharge pressure by flow rate control valve.

AREA OF CONCERN: POOL STRUCTURE

Problem: **Slippery walls and sides**

Likely cause: **Algae bloom in pool:**
Superchlorinate and scrub down walls and floors.

Problem: **Stains on walls and floor**

Likely cause: **Mineral deposits:**
Adjust pH, total alkalinity and add sequestering agents, if necessary drain, scrub and acid wash.

AREA OF CONCERN: SWIMMER COMPLAINTS

Problem: **Eye irritation**

Likely cause: **Chloramines, water quality:**
Remove nitrogenous wastes from pool; adjust pH and total alkalinity.

Problem: **Enamel on swimmers teeth erodes**

Likely cause: **Low pH and total alkalinity:**
Check corrosion of pipes.

Problem: **Discoloration of hair or skin**

Likely cause: **Dissolved copper and iron in pool water:**
Check corrosion of pipes, tanks, and equipment for source of metal.

APPENDIX C
Pool Safety

Swimming pool owners have certain legal liabilities for pool safety as well as a responsibility for maintaining the pool in a sanitary condition. Supervision is one important pool safety element. Another is using posted and enforced guidelines or rules at the pool to help insure that the public is aware of "do's and don'ts" while at poolside. The following are recommendations for setting up a pool safety program.

Chemical Safety

Handling chemicals, mixing dilutions, and making applications to the pool while swimmers are present, are hazards to swimmers. Schedule chemical applications when the public is not present. To prevent contact with undiluted chemicals, no one should be allowed in the water for several hours after an application or until the water is determined safe to use.

Follow Directions

Mix chemicals according to label directions.

Protect Yourself

Wear personal protective equipment including goggles or other protective eyeglasses, non-absorbent gloves and other clothing to protect yourself when handling chemicals.

Self-contained Breathing Apparatus

When working with any acid or chlorine based product, always have a self-contained breathing apparatus available to prevent breathing fumes.

Never add water to chemicals!

When mixing chemicals and water, add the chemical to the water slowly; never add water to the chemical!

Run the Pump When Applying Chemicals

When applying chemicals, make sure the pool's pump is running. If the pump is off, the chemicals cannot mix evenly throughout the water.

Apply Chemicals Near Return Line

When applying chemicals, if appropriate, apply to the water over a return line in the pool—the flow of water helps disperse the chemicals.

Avoid Splashing Chemicals

When applying chemicals to pool water, pour close to the waters' surface to avoid splashing. Slowly pour the liquid into the water to prevent a large amount of chemical from going to the pool bottom. Recap the container over the water to prevent splashing upward onto your clothing or body.

Never Mix Other Chemicals with Chlorine

Warning: a dangerous gas could develop if other chemicals are mixed with chlorine. Never mix chlorine with other pool chemicals.

Store Chemicals Correctly

Always store chemicals in their original containers. If improperly labeled or mixed, fire or accidents could result. Provide adequate ventilation in the storage area. See Chapter 8, Safe Pesticide Handling, in the Core manual (E-2195) for additional storage recommendations.

Clean Up Spills

If a chemical is spilled, clean up the spill immediately. Some spills can cause fires. See Chapter 8, Safe Pesticide Handling, in the Core manual (E-2195) for additional spill clean-up procedures. **NEVER** attempt to neutralize a chemical spill or accident with another chemical. To clean up large spills, professionals trained in chemical spills may be needed. The Michigan Department of Agriculture services a spill hotline (800-405-0101) that can provide emergency help and information. As a safety precaution, post the MDA Emergency telephone number and those of the fire department or first aid/emergency services. See the Emergency Pesticide Information sheet available at the back of this manual.

Properly Dispose of Chemicals

Know how to properly dispose of chemicals, including which can be placed into the sewage system. Certain chemicals including bleach, acids, and flocs should not be flushed into a septic tank system. If you have left over chemicals, applying them to a labeled site (where it is legally intended for application) is one option for getting rid of them. Be sure not to exceed labeled rates or acceptable pool concentrations. If you are uncertain about disposal, check with your local MDEQ pool inspector.

Personal Protection/Precautions

Chemical exposure to the skin or contact with the eyes requires that the contaminated areas be flushed with large quantities of fresh water. Remove any contaminated clothing immediately. See chapter 7, Pesticides and Human Health in the Pesticide Applicator Core Training Manual (E-2195) for more first aid information, and see the Emergency Pesticide Information sheet available at the back of this manual.

Safety Inspection

Many areas in and around the pool pose hazards to pool users. For example, slippery areas of the deck, locker and toilet rooms, pool diving areas, and play areas for younger swimmers are a few of the more hazardous locations that the operator must check carefully. Note: some people who use the pool area may not be swimmers. To protect pool users, put together a checklist identifying areas of the facility where they may be at risk from physical and chemical accidents. Review this list daily and perform daily inspections of these areas. The pool operator should check, date, and initial the list to verify that the inspection was completed. Check the condition of the safety equipment to make sure it is in good condition. Other areas of concern include the ladder, handrails, steps and surrounding deck areas. Use an inspection form detailing all phases of the pool operation.

Diving Safety

Strict supervision may be required at facilities where diving boards and slides are allowed. Post signs stating diving rules where all swimmers can read them. Be sure to examine the structural condition of the diving board, slide, platforms, or other devices for any loose nuts and bolts, hardware, and signs of stress (cracks). If any unsafe condition exists, take the device out of service until corrected.

Since most spinal cord injuries happen in shallow water, always maintain the pool in a condition with clear water throughout the depth of the pool. Cloudy water could prevent a swimmer from judging the water depth. If an accident occurs, the rescue of the swimmer is also hindered by cloudy water. As the pool operator, periodically check the condition of the safety equipment to make sure it is in good condition. For example, check the ring toss buoy and rope, and the securing straps on the spineboard to make sure they have not deteriorated or become rotten. If they have, replace them. The spineboard also must be checked for cracks, splinters and signs of rot.

Personal Hygiene

The elimination or control of infectious organisms is completely dependent upon the continuous maintenance of an adequate and acceptable disinfectant level in all parts of the pool water. Clean and clear water can only be accomplished if the pool users exercise care in keeping contaminates out of the pool. This includes good personal hygiene for every pool user.

Rescue and Safety Equipment

The following list of emergency equipment is needed for the pool and must be located where the public can reach it. A telephone must be available for emergency use. Post emergency phone numbers next to all phones, including public phones. Make sure the address of the pool is posted so that it may be provided to emergency personnel. In addition, a wave pool should have two emergency shut off devices for the waves located at a fixed lifeguard station in case of an emergency. The operator and lifeguards must know how to shut off equipment in an emergency.

Recommended safety equipment includes:

1. A long spineboard with ties, handholds and runners for lifting an injured swimmer. Only certified persons should backboard an injured swimmer from the pool. Never allow the board to be used as a playtoy by swimmers.
2. A one piece, 12-foot rescue pole with blunt ends or with a curved "shepherd's crook" for pulling swimmers out of the water.
3. A $1/4$-inch diameter nylon throwing rope that is $1\frac{1}{2}$ times longer than the pool width and is attached to an 18-inch diameter rescue bag. A U.S. Coast Guard approved ring-toss buoy may be substituted for the rescue bag.
4. A first aid kit used primarily to treat small cuts, bruises and burns, is recommended. Place it where it is visible. Keep it stocked with the following items or their equivalent:
   a. Four units of adhesive bandages, 1 by 3 inches.
   b. Two units of 2-inch bandage compress.
   c. One unit of 3-inch bandage compress.
   d. One unit of 4-inch bandage compress.
   e. Two units of absorbent gauze pad, 3 inches by 3 inches.
   f. One unit of gauze compress, 18 by 36 inches.
   g. Two units of large gauze compress, 24 by 72 inches.
   h. Two units of 4-inch gauze roller bandages.
   i. Two units of triangular bandages.
   j. Scissors.
   k. Tweezers.
   l. Two units of instant ice packs.
   m. Two units of latex disposable gloves.
   n. One unit of adhesive plaster tape.

Other bandages and first-aid supplies could be stocked. It is not recommended to have any medications on hand that could be mistakenly administered. Some emergency personnel suggest not giving water orally to a victim, just moistening their lips, in case there is a possibility of serious injuries.

Of course, the use of the "buddy system" may be the best method to help prevent the possibility of drowning. Encourage users to never swim alone, especially in an unattended pool.

Lifeguards

By law your public swimming pool may be required to provide lifeguard service for the bathers (see table one). See Public Swimming Pools Act 368, Rule 98, and contact MDEQ to determine if lifeguards are mandatory. The responsibility of a lifeguard varies with the individual pool setting. The primary responsibility of a lifeguard is the safety of the bathers. Ensuring safety may include preventing drowning, managing the pool's daily operations, insuring safety, and enforcing the rules of the facility.

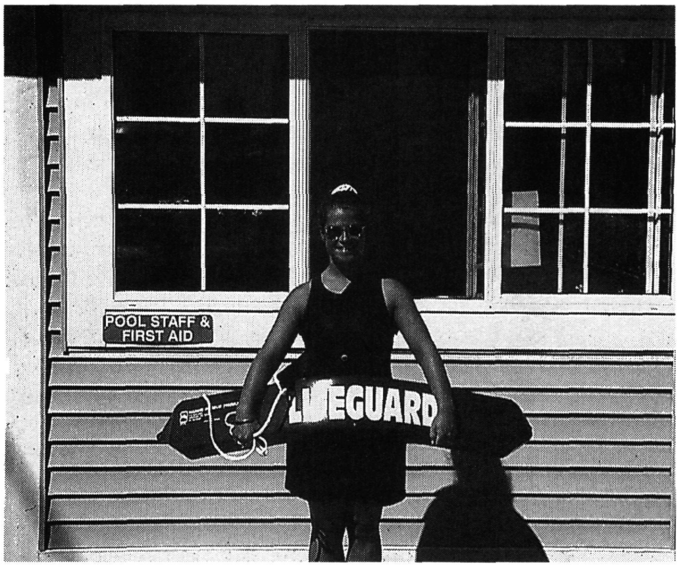


Table One. Lifeguards, Excerpt from Act 368, Public Acts of 1978.

Obtain the complete Act for understanding all requirements for compliance.

R325.2198. Rule 98. (1) Lifeguard service shall be provided at a swimming pool, other than a wading pool or a spa pool, if the swimming pool is owned or operated by a government, a governmental subdivision or agency, a public corporation, or a school, or if the total water surface area within the swimming pool enclosure exceeds 2,300 square feet.

Rule 98. (2) Where lifeguard service is required by subrule (1) of this rule, 1 lifeguard for every 75 people within the swimming pool enclosure shall be on duty I the enclosure when the swimming pool is open for use.

The lifeguard must not only enforce rules outlined by state and local regulations, but also uphold pool guidelines with a high level of responsibility. The pool owner may also have certain rules for which the lifeguard must set the example.

In the event of an injury or drowning, the pool owner(s) might be judged liable if he/she did not take steps necessary to prevent the pool from being overcrowded, unsafe or unsanitary. The owner, lifeguard, pool manager, or other responsible attendant must give due attention to pool safety, sanitation and the personal hygiene of the bathers.

When is a swimming pool unsafe to use?

An unsafe public swimming pool is a detriment to the community and a hazard to its users. The following factors may serve as guidelines for deciding when a pool has become unsafe to the point that it must be closed. Some reasons are more urgent than others are. A single violation might justify closing in one instance and not in another because of additional unlisted factors. Judgement is always necessary to assess the total impact on the users, the management, and the employees if the pool is closed.

Since unsafe conditions can occur when the MDEQ authority is not present or is unaware of such violations, the ultimate responsibility for closing of the facility is placed upon the owner, operator or person in charge.

Conditions that may justify closing a pool temporarily:

1. WATER QUALITY

Disinfectant residual too low or absent:

If the free available chlorine (or bromine) is less than the required minimum of 0.4 ppm (1.0 ppm bromine), the pool should be closed and kept vacated until the residual has been brought to an acceptable level and maintained for at least 24 hours (3 turnovers of the water). The recommended minimum residual level for chlorine is 1.0 ppm, and 2.0 ppm for bromine.

Turbidity:

Water that has become too cloudy or dirty can interfere with normal visibility, and prevent a lifeguard or responsible party from seeing a submerged person. Closing the pool until the condition is corrected may take several turnover periods of the pool water, 24 hours or more. The main drain cover must be visible from 30 feet away.

Algae growth:

Algae growth is unlikely if adequate water quality is maintained. Algae "blooms" normally are not a reason for pool closure unless inadequate disinfection allows cloudiness, water discoloration, and possible slippery surfaces to form. Watch for low residuals of chlorine (or bromine) and slippery conditions. Superchlorination, or higher than acceptable levels of chlorine (and bromine), helps prevent this growth from occurring. Remember to keep the pool vacant at times of superchlorination or any chemical application until determined safe for users.

Known contamination:

If the pool has been contaminated with vomit, feces, or if sewage has directly entered the pool through a backup or accident, close the pool immediately, then drain, scrub, and refill before use. Contact the local MDEQ sanitarian such contamination occurs. If any alternative method for removing the contamination and disinfecting of the water is proposed, the local MDEQ official should issue prior approval before an alternative is used.

Complete draining and cleaning may sound like drastic measures, but remember that the exchange of filtered water for the pool is a continual dilution process. Because of this non-uniform distribution of incoming fresh water, as well as the basic principles of dilution, a considerable portion of the original water, and any pollution in it, usually remains in the pool after many hours of recirculation through the filters required because filtering is likely to be inadequate.

Bacteriological samples:

A series of unacceptable or unsafe bacteria count samples from the pool may indicate a situation requiring pool closure. A single sample is not necessarily significant but may re-confirm the judgement of pool closure at the time of sampling. Conditions may have changed greatly between the time of sample collection and the time when the laboratory results are reported. In such instances, a thorough inspection of the facility may be necessary to evaluate what may have caused the unacceptable samples in the first place. In any case, any pathogenic or indicator organisms found by the sampling are most likely to be of from a swimmer's bowels, skin, mouth, or nose.

Contamination by spitting, clearing the nose:

These habits should not be tolerated in the pool facility. When it occurs, the lifeguard or a responsible party should clear the pool of users until the debris can be skimmed or flushed. The most potent contamination in the pool usually is on the surface of the water, causing eye, ear and throat infections.

Water level:

Contamination can accumulate on the pool water surface if skimming is not effective. This occurs most often if the water level is too low or too high, and gutters and skimmers do not properly function. If the water level drops below the minimum depth for diving or competitive swimming, vacate the pool until the proper level can be reached and maintained.

Glass or foreign object:

Broken glass and clear plastic is very difficult to see underwater and remove completely without leaving splinters or pieces in the pool. If broken glass or plastic gets into the pool, the pool should be drained, the bottom searched for remains, cleaned and refilled.

Chemical conditions:

Using unapproved or excessive quantities of chemicals may require closing and draining the pool. In the case of excessively high disinfectant levels, pH either too high or too low, or other chemical parameters being out of balance, dilution or dissipation may restore the pool to a satisfactory condition of balance.

Sediment in the pool:

Remove any sediment by vacuum or brush to prevent it from becoming re-suspended, which causes turbidity or depletes the disinfectant.

2. SANITATION OF THE FACILITY

Deck or shower areas::

Low spots on the decking where puddling occurs or other slippery areas, are places where accidents can happen. The pool operator or manager should be aware of these areas of "accidental surroundings" and take corrective action before accidents occur. Dirt tracked into the pool water can use up quickly the available disinfectant or could cause a turbidity problem. Persistent failure to correct these hazards is sufficient reason to order the pool closed.

Scum ring, grease build up:

When inadequate cleaning and sanitation have left a film or ring of grease or oil on the interior surface of the walls, floor, skimmers, or gutters, the operator may be required to close the pool for cleaning. Cleansing powders and manual cleaning are usually the remedy for such problems. It is not recommended to keep the pool open while abrasive cleaners and degreasers are used in the pool. Proper down-time for cleaning is the answer to prevent heavy grease and dirt build-up.

Showers, toilet areas:

Proper bather hygiene is essential for keeping body oils, residue soap scum, and other debris out of the pool. If showers are not functioning, or hot water is not available, cleanliness will be sacrificed and the pool should not stay open.

Other hazards:

In a swimming pool environment bathers are susceptible to abrasions, cuts and other injuries because more skin is exposed than usual. Serious infections of minor wounds can result unless extreme care has been taken to eliminate all accident hazards from the entire pool facility. The owner, operator, or other responsible party has the ultimate responsibility to remedy any hazardous situation before it becomes a legal or civil lawsuit due to negligence.

3. WATER TREATMENT EQUIPMENT

Incomplete installation of equipment:

Before any use of the pool, the pool equipment and facilities should be totally functioning, in working order, and have final MDEQ approval. Sometimes minor deficiencies or technicalities may be waived, but follow-up measures to insure the pool facility is acceptable for public use would be required. Before any licensing by the MDEQ is issued, the finished facility must be evaluated for compliance with the submitted and approved construction plans. Legally, no one may enter the pool water until the MDEQ has issued an operation permit.

Outage of equipment:

Because turnover rates and other criteria are based on 24-hour operation, shutting the pump off for more than a few minutes of routine maintenance should be avoided. With regard to nonfunctioning chemical equipment, hand-feeding of disinfectants into the pool should not be allowed for more than 24 hours. Otherwise, the pool should remain vacant until equipment is repaired.

Electrical problems:

Under certain conditions of electrical malfunction, the water in the pool can send an electrical charge through a swimmer's body when the swimmer touches ungrounded metal objects or ungrounded ladders and rails. The pool should be checked by a competent electrician familiar with the latest National Code, Article 680: At no time should an ungrounded appliance or extension cord be permitted anywhere on the pool deck. Because of the lightning hazard, an outdoor pool should be vacated during any electrical storm in the vicinity.

4. SUPERVISION OF BATHERS

Absence fo Lifeguard:

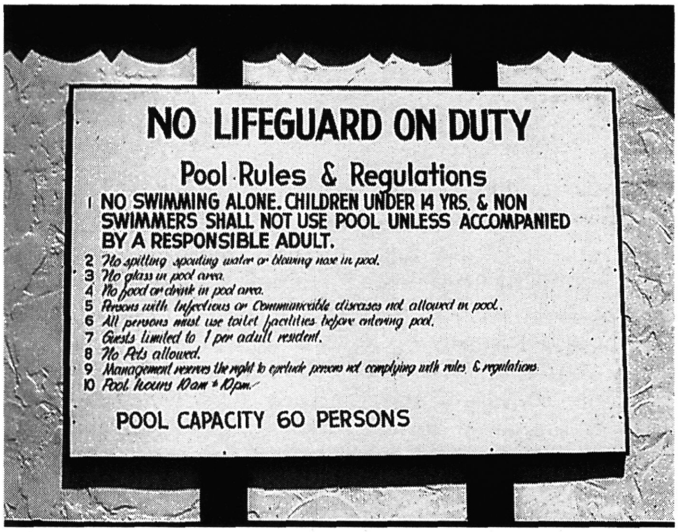
If a pool is not guarded continuously by competent lifesavers, a submersion accident is more likely to occur and a fatality result. In a worse case scenario, if an untrained person attempts a water rescue in deep water, he/she may become a second drowning victim. This is especially true of pools with water deeper than five feet. However, with proper life saving equipment present, a calm and competent non-swimmer on the deck can often furnish aid successfully without such risk. In no case, and regardless of ability of the swimmer, should anyone be allowed to swim alone or without observation; even the best swimmers can develop cramps or asphyxiate. If lifeguard service is required but that person is absent, the unguarded pool should be closed until the proper supervision is on duty. This includes being suitably dressed to enter the water in an emergency.

Lack of Inspection of Bathers:

Every person seeking to enter the pool should be inspected by the lifeguard or attendant to insure cleanliness and freedom from obvious signs of disease, infection or, especially, respiratory illness.

Lack of Discipline:

In extreme cases, a pool might be closed temporarily to control excessive horseplay or other discipline problems. Ordinarily, only the offenders should be evicted unless vandalism has created hazards to others. Admitting more bathers than the allowable maximum bathing load often leads to such problems.



Dogs or Other Animals in Pool:

If this problem arises, the pool should be ordered closed on the same basis as for human pollution.

5. GENERAL

The pool management has the basic responsibility to close the swimming pool or wading pool whenever conditions, which are detrimental to the health and safety of persons using it, exist. In addition to the situations discussed previously, any dangerous condition such as loose masonry, coping, deck materials, damaged diving structure, fallen trees or wires require that the pool be closed. MDEQ officers and sanitarians may be obliged to order such closing if the management neglects to do so. Epidemics of certain diseases in the community also may require MDEQ officers to take action.

APPENDIX D
Spinal Injuries

Spinal injuries happen most frequently at the shallow end of the pool, or where the bottom slopes into the deeper water. These accidents are more common where lifeguards or other supervisory personnel are not present.

If a swimmer is injured, allow only trained medical personnel to evaluate the extent of the injuries. In most cases, lifeguards do not have the necessary training or equipment to properly evaluate a spinal injury.

There are several techniques used to stabilize a victim's spine. Regardless of the technique you are familiar with, it is strongly recommended that you contact the local Red Cross chapter, fire department or emergency medical service in your area to assist the injured person. Find out how these agencies want you to handle the victim, if at all! There may be more injury caused by good intentions if the victim is moved beyond recommended measures.

The following procedures are recommended when a spinal injury is suspected:

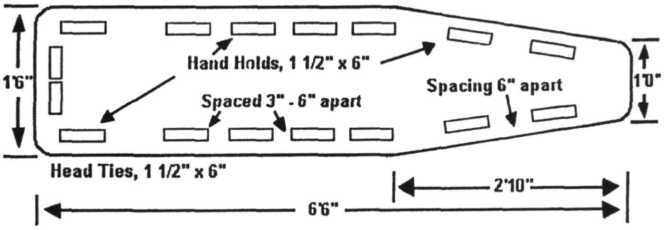
1. Use your facilities emergency action plan and have someone call for emergency help.
2. Carefully approach the victim in the water, disturbing the water as little as possible.
3. Reduce or prevent any movement of the victim's spine.
4. Move the victim to shallow water by following Red Cross guidelines or equivalent.
5. Secure the victim to the spineboard. Only trained professionals should move the victim after this point.
6. Follow the Red Cross or equivalent A, B, C's of life saving: open Airway, establish Breathing, maintain Circulation.
7. Remove the victim from the water.
8. Keep the victim warm until professional help arrives.
9. Monitor the victim for shock and hypothermia.

Spineboards

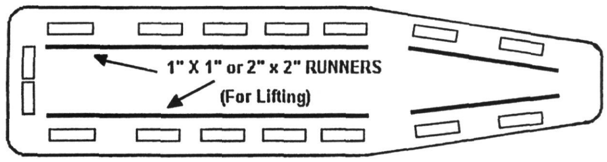
Spineboards are available commercially or can be fabricated. Spineboards must be at least one inch thick or possibly constructed with marine laminated plywood. If painting the board, use a non-metallic paint in case x-rays are required while the victim is on the board. Varnish the board so that the surface is weatherproof. Openings need to be placed along the length of the board for use as hand holds, and for tie down straps. Materials for the ties should be durable with no sharp edges. A total of 6 ties are recommended to secure the victim to the board properly. Because most material decays from sunlight or chemical exposure, check them regularly and replace if necessary. If metal securing devises are used, check them often for corrosion.

Glue or secure wooden runners of either 1" × 1", or 2" × 2" to the board's bottom. This allows your hands to reach underneath the board to help lift the victim from a flat surface.

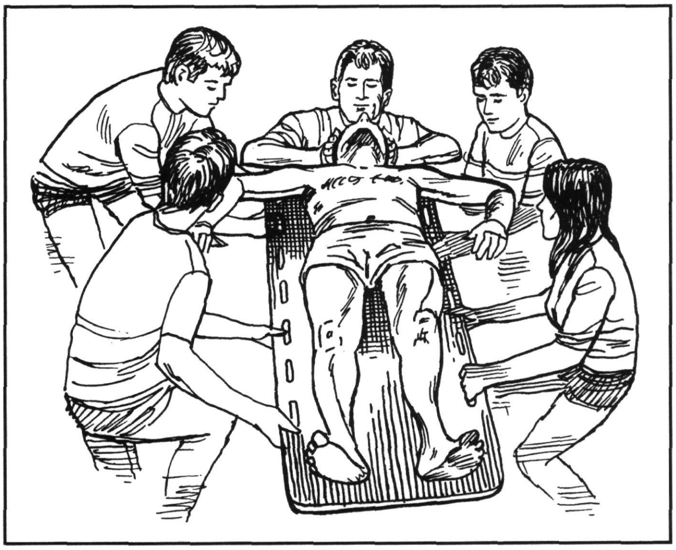
SUGGESTED SPINEBOARD SPECIFICATIONS



SPINEBOARD (BOTTOM VIEW)



To secure a victim to a spineboard, follow American Red Cross spineboarding procedures, or equivalent.



American Red Cross Lifeguard Training, copyright 1983 by American National Red Cross Washington, D.C. ISN 0-86536-057-x figure 9-42.

Spineboard with approved head immobilizer.

Have available specially designed cervical collars and head immobilizers or equivalent devices to stabilize the head and neck. Allow trained professionals to put these on the victim.

Locate the spineboard where pool users have access to it in case of an emergency. Do not allow the spineboard to be used as a play-toy.

APPENDIX E
SUPERVISORY POOL PERSONNEL

To operate a public swimming pool so that it meets water quality standards, it is essential that qualified personnel be available for water testing, water treatment equipment operation and maintenance of the pool equipment and facilities. The public swimming pool owner has certain responsibilities to ensure this is accomplished.

First, a qualified person must test the water and operate the water treatment equipment. As a minimum this requires:

- Pesticide Applicator Certification in category 5A of Swimming Pool Pest Management through the Michigan Department of Agriculture (517) 373-1087.
- An ability to accurately use test equipment to check disinfectant levels, pH, total alkalinity and cyanuric acid.
- An understanding of the required water quality standards for disinfection levels, pH and cyanuric acid, (if applicable).
- An understanding of the swimming pool recirculation, filtration, procedures for backwashing, and disinfection systems including required flow rate, dilution of pool disinfection chemicals, and types and amounts of chemicals to adjust pH levels.
- An understanding of the requirement to close the swimming pool from use if the pool becomes polluted with feces, vomit, sewage, or other materi als, as well as for swimmer safety hazards.
- Responsibility for the completion of daily operation reports.

In addition:

A qualified person must be readily available when the swimming pool is open for use. The qualified person should be in the pool area at all times when the pool is open.

In locations such as apartment complexes and condominium developments that have an office open during pool operation hours, the supervision requirement could be met if office personnel are available to contact a qualified person via a "beeper" and the qualified person is within a 15 minute response range. In cases where there is no office, signs must be posted indicating where the qualified person may be contacted. Other arrangements as approved by the Michigan Department of Environmental Quality may be made.

Pool operators must maintain pool equipment and facilities in a safe and satisfactory condition at all times.

If the above criteria are not continuously met, a designated local MDEQ official may order the owner of a public pool to prohibit any person from using it.

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

SWIMMING POOL OPERATION REPORT

(See reverse side for instructions)

Name of Establishment ____

Municipality ______________________________ **For Month of** ____________ 19 ______

	Pool Usage			Cleaning			Water Treatment							Water Conditions										
	No of Hours	Number of People		Pool Bottom	Deck	Bathhouse	Water Added in inches	Filters		Flow Rate, in gpm		Chemical Addition		Disinfectant Residuals ☐ Chlorine or ☐ Bromine						pH	Cyanuric Acid, mg/L or ppm		Temperatures	
		Maximum	Total					No. Hours Operated	Wash	Minimum	Maximum	Disinfectant, lbs. or gals.	lbs. or gals.	Time	mg/L or ppm	Time	mg/L or ppm	Time	mg/L or ppm				Water	Air
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
2																								
3																								
4																								
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Bacteriologic Analysis					
Date	Residual mg/L	pH	No. of People	Standard Plate Count	Coliform Index
26	27	28	29	30	31

Remarks: ____

This report is submitted in compliance with Act 368, 1978, and is true to the best of my knowledge.

Signature ______________________ Date ______________

SP-63 (Rev. 1/89)

Authority Act 368. P.A. 1978

INSTRUCTIONS FOR USING SWIMMING POOL OPERATION REPORTS

Rule 325.2199 is: "A swimming pool operator shall record daily, on a report form furnished by or acceptable to the department, the swimming pool operational data and information about rescues, submersions, and accidents given medical attention. The department or a designated local health department may require the operator to submit a completed operation report to the department or the designated local health department within 10 days after the end of each month in which the swimming pool is in operation." Failure to complete this form is a violation of Act 368 P.A. 1978 and is subject to the penalties as outlined in the Act.

COLUMN NUMBER

POOL USAGE

2 Record the number of hours the pool is open for use.

3 Record the maximum number of people using the pool at one time. Include both those in the water and on the deck.

4 Record the total number of swimmers at the pool during the day.

CLEANING

5 Check this when the pool bottom is vacuumed or otherwise cleaned.

6-7 Check these spaces when the respective areas are cleaned.

WATER TREATMENT

8 Record the inches of depth of water added to the pool. The number of gallons of water may be entered instead. If the water is added automatically and cannot be measured, write "automatic" in the column.

9 Record the number of hours the water is recirculated, filtered, and disinfected. Rule 325.2196 requires it to be 24 hours per day, without interruption except for maintenance and repairs.

10 Check this when the filters are cleaned. Multiple filters should be cleaned the same day.

11-12 Record the flow meter readings, in gallons per minute.

13 Record the total amount of disinfectant (chlorine or bromine) added to the feeding equipment during the day. Indicate if the measurement is pounds of dry chemical or gallons of liquid. Rule 325.2196 requires the disinfectant to be applied continuously.

14 If an additional chemical is used, record the amount added. Indicate the chemical name or type and whether the measurement is pounds or gallons.

WATER CONDITIONS

15-20 Indicate whether the disinfectant residuals are chlorine or bromine. Record the time and the reading each time the residual is tested. The water should be tested before the swimming pool is opened for the day and at least twice more during the day. The water for testing should be from the pool itself rather than the recirculation system.

The required **minimum** disinfectant residuals, in milligrams per liter (mg/L) or parts per million (ppm), depend on the pH of the water and are:

Disinfectant	Type of Residual	pH 7.2-7.6	pH 7.7-8.0
bromine	bromine	1.0	2.0
chlorine	free available chlorine	0.4	1.0
chlorinated cyanurate	free available chlorine	1.0	1.5

21 Test and record the pH of the swimming pool water daily.

22 If cyanuric acid or a chlorinated cyanurate is used, test and record the cyanuric acid level of the pool water at least weekly. A concentration of 25 mg/L is considered necessary for the stabilization of chlorine. Higher levels are not advantageous and must not exceed 100 mg/L.

23 Identify and record any other pool water characteristic tested.

24-25 Record the water and air temperatures, in degrees Fahrenheit.

The water temperature may not be higher than 86° F. except with health department approval and must not exceed 104° F. The air temperature generally should be 3° F. to 5° F. higher than the water temperature.

BACTERIOLOGIC ANALYSIS

Rule 325.2195 requires water samples for bacteriologic analysis to be collected at least once each week, and more often if directed by the health department for unusual conditions, but the sampling frequency may be reduced by the health department if there is an acceptable history of operation and water quality. The swimming pool owner or operator is responsible for the collection and analysis of the samples.

26 Record the date the sample is collected.

27 Test and record the chlorine or bromine residual when the sample is collected.

28 Test and record the pH of the pool water when the sample is collected.

29 Record the number of people in the pool when the sample is collected. These water samples should be collected while people are in the pool and preferably during periods of peak pool usage.

30 Record the standard plate count as determined by the laboratory analysis.

31 Record the coliform index as determined by the laboratory analysis.

Rule 325.2195 states: "The presence of organisms of the coliform group or a standard plate count of more than 200 bacteria per milliliter, or both, in 2 consecutive samples or in more than 10% of the samples in a series as shown by valid tests, is unacceptable water quality."

REMARKS

Record any unusual situation such as an equipment failure, draining of the pool, or an accident requiring first aid or medical attention.

SUBMITTAL. Within 10 days after the end of the month, submit the completed operation report to the local health department if required by that department.

MICHIGAN DEPARTMENT OF PUBLIC HEALTH
SWIMMING POOL INSPECTION REPORT
By Authority of Act 368, P.A. 1978, as amended, and the Rules

Name of Establishment ____________________

Street Location ____________________

City or Township ____________________

Name of Person In Charge ____________________

Title ____________________

Inspection Type: ☐ Seasonal Opening ☐ Routine ☐ Initial ☐ Follow-up ☐ Complaint ☐ Other ________

SP ☐☐ ☐☐☐☐ ☐ & ☐

☐ / ☐ Indoor	☐ / ☐ Swim	☐ / ☐ Spa
☐ / ☐ Outdoor	☐ / ☐ Wade	☐ / ☐ Slide
☐ / ☐ Combination	☐ / ☐ Dive	☐ / ☐ Other ________

☐ / ☐ Chlorine
or ___ / ___ mg/L pH ___ / ___
☐ / ☐ Bromine

Flow rate	___ / ___ gpm	Number of bathers	___ / ___	mg/L
Water temp.	___ / ___ °F	Stabilizer	___ / ___	mg/L
Alkalinity	___ / ___ mg/L	Hardness	___ / ___	mg/L

Samples for bacteriologic analysis collected ___ / ___

Remarks:

Health Department Representative ____________________

Date ________ Time ________ Scheduled Reinspection Date ________

Report Received By ____________________

Approved for Operation? ☐ / ☐ YES
☐ / ☐ NO
☐ / ☐ CONDITIONAL ________

___ / ___ 1. Doors or gates comply [28 (2) & 91 (1)].
___ / ___ 2. Pool enclosure complies [28].
___ / ___ 3. Deck clean, drains, and good condition [29 & 91 (3)].
___ / ___ 4. Foot sprays comply [78].
___ / ___ 5. Drinking fountain complies [31].
___ / ___ 6. Hose bibs comply [81 (1)].
___ / ___ 7. Depth markers and "No Diving" provided [32 (2)].
___ / ___ 8. Diving facilities comply [33].
___ / ___ 9. Ladders and stairways in compliance [34].
___ / ___ 10. Pool water clarity and quality in compliance [94].
___ / ___ 11. Pool sides and bottom smooth and clean [22 (3) & 91 (3)].
___ / ___ 12. Pool structure in good condition [22 & 91 (3)].
___ / ___ 13. Water level suitable for skimming [96 (3)].
___ / ___ 14. Overflow system or skimmers clean and functioning [43 & 44].
___ / ___ 15. Pool water inlets comply [41].
___ / ___ 16. Main outlets comply [42].
___ / ___ 17. Lifeguards on duty, or sign [98].
___ / ___ 18. Bather load within limit and sign [93].
___ / ___ 19. Hazardous objects, food, or drink controlled [92 (7)].
___ / ___ 20. Lifeline complies [32 (3) & 91 (2)].
___ / ___ 21. Safety equipment complies and on hand [65 & 91 (2)].
___ / ___ 22. Telephone available and evident [65 (4)].

Bath-house

___ / ___ 23. Shower, toilet, or dressing rooms clean [91 (3)].
___ / ___ 24. Bathhouse materials and fixtures comply [74, 75, & 76].
___ / ___ 25. Hot water and soap provided [25 (2) & 91 (6)].

Mechanical Equipment

___ / ___ 26. Mechanical equipment housed [71].
___ / ___ 27. Piping and arrows comply [37].
___ / ___ 28. Pump adequate and functioning properly [36, 45, & 96 (1)].
___ / ___ 29. Flow rate control valve complies [38 (1)].
___ / ___ 30. Flow meter functioning, and rate adequate [38 (2) & 96 (1)].
___ / ___ 31. Filters and gauges functioning properly [51, 54, & 96 (1)].
___ / ___ 32. Chemical feeder functioning properly [57, 96 (1), & (4)].
___ / ___ 33. Spa air and water agitation systems comply [46].
___ / ___ 34. Water heater and thermometers comply [61 & 81 (3)].
___ / ___ 35. Vacuum cleaner on hand [63].
___ / ___ 36. Chemicals stored properly [91 (4)].
___ / ___ 37. Water supply adequate and protected [25 & 26].
___ / ___ 38. Wastewater facilities adequate [27].

General Operation

___ / ___ 39. Test kits suitable and used [59 & 94].
___ / ___ 40. Operator readily available [97].
___ / ___ 41. Operation permit fee paid or permit displayed [Sec. 12527].
___ / ___ 42. Operation reports used [99].
___ / ___ 43. Water samples collected on schedule [95].
___ / ___ 44. No modifications made without construction permit [Sec. 12525].

APPENDIX H
Convenient Conversion Factors

Multiply	By	To Get
Acres	0.405	Hectares
Acres	4,047.0	Square Meters
Acres	4,840.0	Square Yards
Acres-feet	43,560.0	Square feet
Acre-feet	1,233.49	Cubic Meters
Acre-feet	43,560.0	Cubic Feet
Acre-feet	325,850.58	Gallons
Bushels	0.0461	Cubic yards
Bushels	1.2437	Cubic feet
Bushels	4.0	Pecks
Bushels	32.0	Quarts (dry)
Bushels	35.24	Liters
Bushels	64.0	Pints (dry)
Bushels	2,150.42	Cubic inches
Centimeters	0.3627	Inches
Centimeters	0.01	Meters
Centimeters	10.0	Millimeters
Cubic centimeters	0.0610	Cubic inches
Cubic centimeters	0.03381	Ounces (liquid)
Cubic centimeters	1.0	Milliliters of water
Cubic centimeters	1.0	Grams of water
Cubic feet	0.0283	Cubic meters
Cubic feet	0.0370	Cubic yards
Cubic feet	0.8040	Bushels
Cubic feet	7.4805	Gallons
Cubic feet	25.71	Quarts (dry)
Cubic feet	28.32	Liters
Cubic feet	29.92	Quarts (liquid)
Cubic feet	51.42	Pints (dry)
Cubic feet	59.84	Pints (liquid)
Cubic feet	62.4	Pounds of water
Cubic feet	1,728.0	Cubic inches
Cubic feet	28,317.0	Cubic centimeters
Cubic meters	1.308	Cubic yards
Cubic meters	35.31	Cubic feet
Cubic meters	264.2	Gallons
Cubic meters	1,000.0	Liters
Cubic meters	1,057.0	Quarts (liquid)
Cubic meters	2,113.0	Pints (liquid)
Cubic meters	61,023.0	Cubic inches
Cubic meters	1,000,000.0	Cubic centimeters
Cubic inches	0.000016	Cubic meters
Cubic inches	0.0005	Bushels
Cubic inches	0.0006	Cubic feet
Cubic inches	0.0019	Pecks (dry)

Multiply	By	To Get
Cubic inches	0.0037	Gallons (dry)
Cubic inches	0.0043	Gallons (liquid)
Cubic inches	0.0149	Quarts (dry)
Cubic inches	0.0164	Liters
Cubic inches	0.0173	Quarts (liquid)
Cubic inches	0.0298	Pints (dry)
Cubic inches	0.0346	Pints (liquid)
Cubic inches	0.0361	Pounds of water
Cubic inches	0.5540	Ounces (liquid)
Cubic inches	16.3872	Cubic centimeters
Cubic yards	0.7646	Cubic meters
Cubic yards	21.71	Bushels
Cubic yards	27.0	Cubic feet
Cubic yards	202.0	Gallons (liquid)
Cubic yards	807.9	Quarts (liquid)
Cubic yards	1,616.0	Pints (liquid)
Cubic yards	7,646.0	Liters
Cubic yards	46,656.0	Cubic inches
Cups	0.25	Quarts (liquid)
Cups	0.5	Pints (liquid)
Cups	8.0	Ounces (liquid)
Cups	16.0	Tablespoons
Cups	48.0	Teaspoons
Cups	236.5	Milliliters
Feet	0.3048	Meters
Feet	0.3333	Yards
Feet	12.0	Inches
Feet	30.48	Centimeters
Feet per minute	0.01136	Miles per hour
Feet per minute	0.01667	Feet per second
Feet per minute	0.01829	Kilometers per hour
Feet per minute	0.3048	Meters per minute
Feet per minute	0.3333	Yards per minute
Feet per minute	60.0	Feet per hour
Gallons	0.00378	Cubic meters
Gallons	0.1337	Cubic feet
Gallons	3.785	Liters
Gallons	4.0	Quarts (liquid)
Gallons	8.0	Pints (liquid)
Gallons	8.337	Pounds
Gallons	128.0	Ounces (liquid)
Gallons	231.0	Cubic inches (liquid)
Gallons	269.0	Cubic inches (dry)
Gallons	3,785.0	Cubic centimeters

Multiply	By	To Get
Gallons of water	0.0038	Cubic meters
Gallons of water	0.0049	Cubic yards
Gallons of water	0.1337	Cubic feet
Gallons of water	3.7853	Kilograms
Gallons of water	8.3453	Pounds of water
Gallons of water	3,785.3446	Grams
Grains	0.0648	Grams
Grams	0.001	Kilograms
Grams	0.0022	Pounds
Grams	0.0353	Ounces
Grams	15.53	Grains
Grams	1,000.0	Milligrams
Grams per liter	10.0	Percent
Grams per liter	1,000.0	Parts per million
Hectares	2.47	Acres
Hectares	10,000.0	Square meters
Hectares	11,954.8	Square yards
Hectares	107,593.2	Square feet
Inches	0.0254	Meters
Inches	0.02778	Yards
Inches	0.08333	Feet
Inches	2.54	Centimeters
Kilograms	0.0011	Tons
Kilograms	2.205	Pounds
Kilograms	35.28	Ounces
Kilograms	1,000.0	Grams
Kilometers	0.6214	Miles
Kilometers	1,000.0	Meters
Kilometers	1,093.611	Yards
Kilometers	3,280.833	Feet
Kilometers per hour	0.6214	Miles per hour
Kilometers per hour	16.6667	Meters per minute
Kilometers per hour	18.2268	Yards per minute
Kilometers per hour	54.6806	Feet per minute
Liters	0.001	Cubic meters
Liters	0.0353	Cubic feet
Liters	0.2642	Gallons (liquid)
Liters	1.0	Kilograms of water
Liters	1.057	Quarts (liquid)
Liters	2.113	Pints (liquid)
Liters	33.8143	Ounces
Liters	61.02	Cubic inches
Liters	1,000.0	Cubic centimeters
Liters	1,000.0	Grams of water

Multiply	By	To Get
Meters	0.001	Kilometers
Meters	1.094	Yards
Meters	3.281	Feet
Meters	39.37	Inches
Meters	100.0	Centimeters
Meters	1,000.0	Millimeters
Metric tons	1.1	Tons (U.S.)
Metric tons	1,000.0	Kilograms
Metric tons	2,204.6	Pounds
Metric tons	1,000,000.0	Grams
Miles	1.6093	Kilometers
Miles	1,609.3	Meters
Miles	1,760.0	Yards
Miles	5,280.0	Feet
Miles per hour	1.467	Feet per second
Miles per hour	1.6093	Kilometers/ hour
Miles per hour	26.8217	Meters per minute
Miles per hour	29.3333	Yards per minute
Miles per hour	88.0	Feet per minute
Miles per minute	26.82	Meters per second
Miles per minute	29.333	Yards per second
Miles per minute	88.0	Feet per second
Milliliters	0.00105	Quarts (liquid)
Milliliters	0.0021	Pints (liquid)
Milliliters	0.0042	Cups (liquid)
Milliliters	0.0338	Ounces (liquid)
Milliliters	0.0676	Tablespoons
Milliliters	0.2029	Teaspoons
Milliliters	1.0	Cubic centimeters of water
Milliliters	1.0	Grams of water
Ounces (liquid)	0.00781	Gallons
Ounces (liquid)	0.03125	Quarts (liquid)
Ounces (liquid)	0.0625	Pints (liquid)
Ounces (dry)	0.0625	Pounds
Ounces (liquid)	0.125	Cups (liquid)
Ounces (liquid)	1.805	Cubic inches
Ounces (liquid)	2.0	Tablespoons
Ounces (liquid)	6.0	Teaspoons
Ounces (dry)	28.3495	Grams
Ounces (liquid)	29.573	Milliliters
Ounces (dry)	437.5	Grains
Parts / million (PPM)	0.0001	Percent
Parts per million	0.001	Liters/cubic meter
Parts per million	0.001	Grams per liter

Multiply	By	To Get
Parts per million	0.001	Milliliters per liter
Parts per million	0.013	Ounces per 100 gallons of water
Parts per million	0.0584	Grains per US gallon
Parts per million	0.3295	Gallons per acre-foot of water
Parts per million	1.0	Milligrams/ liter
Parts per million	1.0	Milligrams per kilogram
Parts per million	1.0	Milliliters per cubic meter
Parts per million	2.7181	Pounds per acre-foot of water
Parts per million	8.345	Pounds per million gallons of water
Pecks	0.25	Bushels
Pecks	8.0	Quarts (dry)
Pecks	16.0	Pints (dry)
Pecks	537.605	Cubic inches
Percent (%)	1.33	Ounces (dry) per gallon of water
Percent	8.34	Pounds per 100 gallons of water
Percent	10.00	Grams per kilogram
Percent	10.00	Grams per liter
Percent	10,000.00	Parts per million
Pints (dry)	0.0156	Bushels
Pints (dry)	0.0625	Pecks
Pints (liquid)	0.125	Gallons
Pints (liquid)	0.4735	Liters
Pints (liquid)	0.5	Quarts (liquid)
Pints (dry)	0.5	Quarts (dry)
Pints (liquid)	2.0	Cups
Pints (liquid)	16.0	Ounces (liquid)
Pints (liquid)	28.875	Cubic inches (liquid)
Pints (dry)	33.6003	Cubic inches (dry)
Pounds	0.0005	Tons
Pounds	0.4535	Kilograms
Pounds	16.0	Ounces
Pounds	453.5924	Grams
Pounds	7,000.0	Grains
Pounds of water	0.0160	Cubic feet
Pounds of water	0.1198	Gallons
Pounds of water	0.4536	Liters
Pounds of water	27.693	Cubic inches
Quarts (liquid)	0.00094	Cubic meters
Quarts (liquid)	0.0012	Cubic yards

Multiply	By	To Get
Quarts (dry)	0.03125	Bushels
Quarts (liquid)	0.0334	Cubic feet (liquid)
Quarts (dry)	0.0389	Cubic feet (dry)
Quarts (dry)	0.125	Pecks
Quarts (liquid)	0.25	Gallons (liquid)
Quarts (liquid)	0.9463	Liters
Quarts (liquid)	2.0	Pints (liquid)
Quarts (dry)	2.0	Pints (dry)
Quarts (liquid)	2.0868	Pounds of water
Quarts (liquid)	4.0	Cups
Quarts (liquid)	32.0	Ounces (liquid)
Quarts (liquid)	57.75	Cubic inches (liquid)
Quarts (dry)	67.20	Cubic inches (dry)
Square feet	0.000009	Hectares
Square feet	0.000023	Acres
Square feet	0.0929	Square meters
Square feet	0.1111	Square yards
Square feet	144.0	Square inches
Square inches	0.00064	Square meters
Square inches	0.00077	Square yards
Square inches	0.00694	Square feet
Sq. kilometers	0.3861	Square miles
Sq. kilometers	100.0	Hectares
Sq. kilometers	247.104	Acres
Sq. kilometers	1,000,000.0	Square meters
Sq. kilometers	1,195,982.7	Square yards
Sq. kilometers	10,763,865.0	Square feet
Square meters	0.0001	Hectares
Square meters	1.308	Square yards
Square meters	10.765	Square yards
Square meters	1,549.9669	Square feet
Square miles	2.5899	Square kilometers
Square miles	258.99	Hectares
Square miles	640.0	Acres
Square miles	2,589,735.5	Square meters
Square miles	3,097,600.0	Square yards
Square miles	27,878,400.0	Square feet
Square yards	0.00008	Hectares
Square yards	0.00021	Acres
Square yards	0.8361	Square meters
Square yards	9.0	Square feet
Square yards	1,296.0	Square inches
Tablespoons	0.0625	Cups
Tablespoons	0.5	Ounces
Tablespoons	3.0	Teaspoons
Tablespoons	15.0	Milliliters

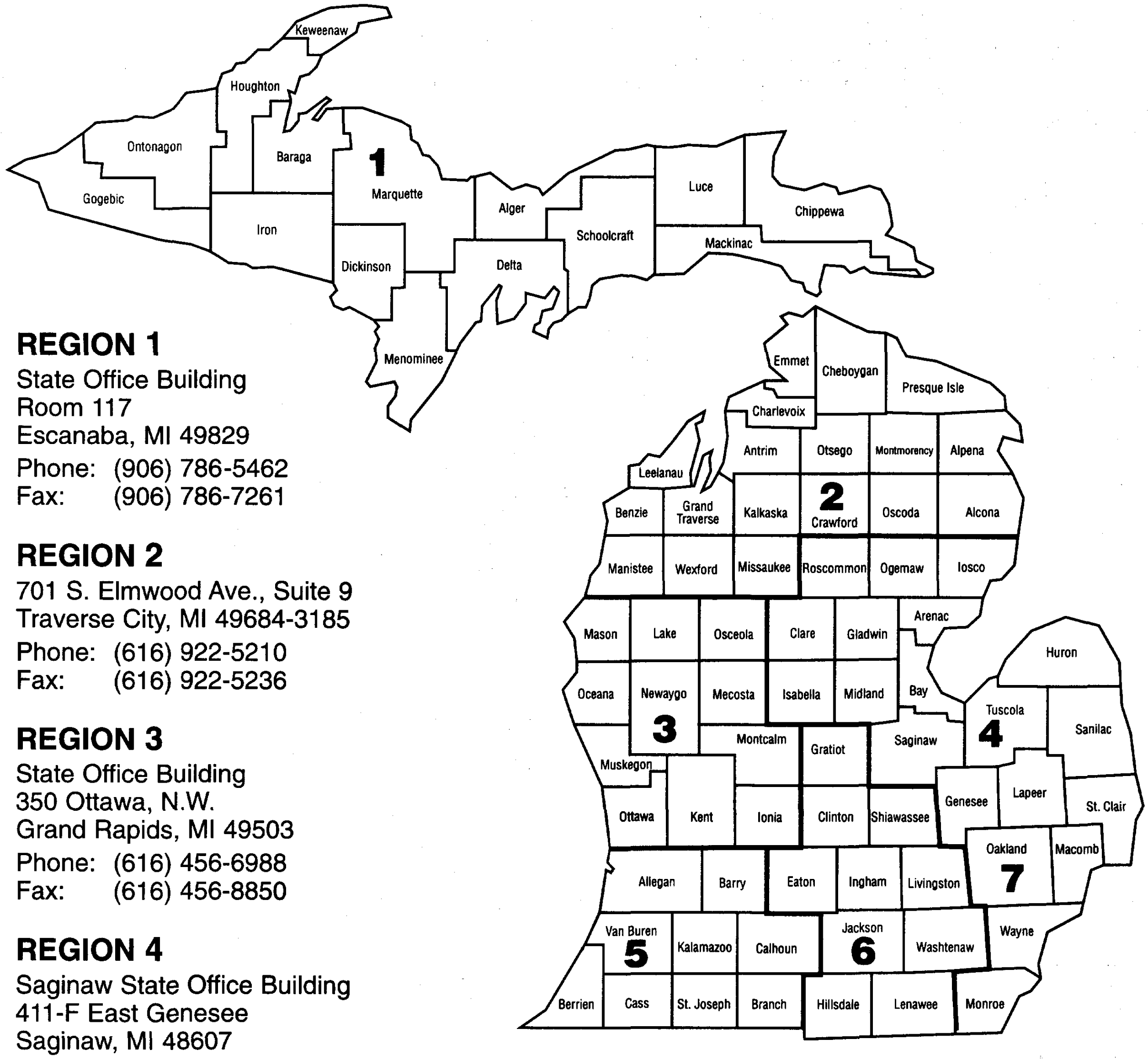
Multiply	By	To Get
Teaspoons	0.0208	Cups
Teaspoons	0.1667	Ounces
Teaspoons	0.3333	Tablespoons
Teaspoons	5.0	Milliliters
Tons	0.907	Metric ton
Tons	907.1849	Kilograms

Multiply	By	To Get
Tons	2,000.0	Pounds
Tons	32,000.0	Ounces
Yards	0.000568	Miles
Yards	0.9144	Meters
Yards	3.0	Feet
Yards	36.0	Inches

APPENDIX I

MICHIGAN DEPARTMENT OF AGRICULTURE
PESTICIDE & PLANT PEST MANAGEMENT DIVISION

P.O. BOX 30017
LANSING, MICHIGAN 48909
(517) 373-1087



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Grand Rapids, MI 49503
Phone: (616) 456-6988
Fax: (616) 456-8850

REGION 4
Saginaw State Office Building
411-F East Genesee
Saginaw, MI 48607
Phone: (517) 758-1778
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REGION 5
4032 M-139, Building 116
St. Joseph, MI 49085-9647
Phone: (616) 428-2575
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REGION 6
611 W. Ottawa
North Ottawa Building
Lansing, MI 49833
Phone: (517) 373-1087
Fax: (517) 335-4540

REGION 7
Lahser Center Building
26400 Lahser Road
Southfield, MI 48034
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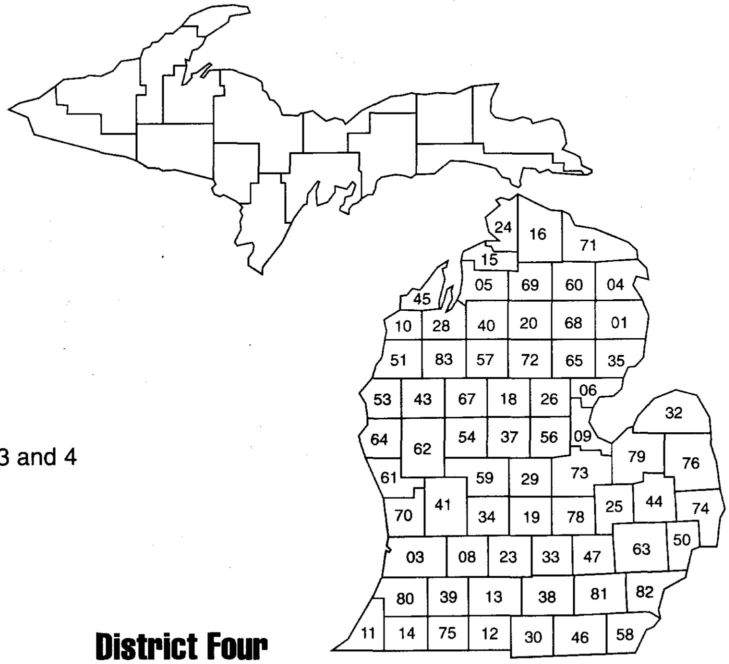
Fax: (810) 356-0374

APPENDIX J

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
DRINKING WATER & RADIOLOGICAL PROTECTION DIVISION
ENVIRONMENTAL HEALTH SECTION-SWIMMING POOL SPECIALISTS



Nancy Allen (517) 335-8278
Secretary for District 1 and 2

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John Fiero
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(63) Oakland

David McCuen
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(25) Genesee
(35) Iosco
(65) Ogemaw
(68) Oscoda

Ken Jewison
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(04) Alpena
(16) Cheboygan
(44) Lapeer
(60) Montmorency
(71) Presque Isle
(82) Wayne

District Two

Jon Caterino
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(46) Lenawee
(47) Livingston
(50) Macomb
(58) Monroe
(81) Washtenaw

Jerry Drake
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(12) Branch
(30) Hillsdale
(38) Jackson
(73) Saginaw
(75) St. Joseph

Holly Mercer
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(09) Bay
(32) Huron
(33) Ingham
(74) St. Clair
(76) Sanilac
(79) Tuscola

Rosemary Scarcella
(517) 335-8282
Secretary for District 3 and 4

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(51) Manistee
(53) Mason
(56) Midland
(70) Ottawa

John Long
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(06) Arenac
(18) Clare
(26) Gladwin
(37) Isabella
(54) Mecosta
(67) Osceola
(72) Roscommon

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(14) Cass
(19) Clinton
(29) Gratiot
(59) Montcalm
(61) Muskegon
(80) Van Buren

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Ben McGeachy
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(05) Antrim
(10) Benzie
(15) Charlevoix
(24) Emmet
(28) Grand Traverse
(39) Kalamazoo
(45) Leelanau
(69) Otsego

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(40) Kalkaska
(43) Lake
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(62) Newaygo
(64) Oceana
(83) Wexford

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(11) Berrien
(13) Calhoun
(34) Ionia
(78) Shiawassee

SPECIAL PROGRAMS:

Public Swimming Pool Program

Paul Sisson
(517-335-8306)

Teresa Fry, Secretary
(517-335-8296)

APPENDIX K

The following operational guidelines were provided by the Michigan Department of Environmental Quality, formerly the Michigan Department of Public Health. This appendix supplements the information found in the chapters of this manual. This is an outline of some of the most pertinent information found in the Public Swimming Pool Rules of Act 368. Refer to a complete copy of Public Swimming Pool Rules of Act 368 to understand all of your obligations as a swimming pool operator.

GUIDELINES FOR PUBLIC SWIMMING POOL OPERATORS

The Michigan *Public Swimming Pool Rules* of Act 368, P.A. 1978, Michigan Public Health Code, sets forth several specific requirements regarding operational practices and procedures for public swimming pools. Several of the more important requirements are listed below.

WATER QUALITY STANDARDS

Disinfection

Disinfection is a chemical process of destroying potentially harmful organisms not removed by the filtration equipment. A disinfectant is needed at a low level, 24 hours per day whenever the pool is operating. The effective level of disinfection is measured in parts per million (ppm). A suitable disinfectant level shall be maintained throughout the swimming pool water and be tested, as suggested (3 times/day). Recommended disinfectant levels for different pH ranges include:

Disinfectant Type	Michigan Minimum Level	Maximum Level
	7.2 – 7.6	7.7 – 8.0
Bromine	1.0 PPM	2.0 PPM
Chlorine	0.4 PPM	1.0 PPM
Chlorinated Cyanurate*	1.0 PPM	1.5 PPM

*When a chlorinated cyanurate is used, the cyanuric acid level should range between 20-70 ppm, and shall not exceed 100 ppm. Test the cyanuric acid level weekly, recording the level on the operational report.

The chemicals used in disinfection are in liquid, granular, or solid tablet form. The chemical is required to be fed through a chemical feeder for normal pool disinfection.

The *free* available chlorine or bromine residual is measured using a D.P.D. test kit standardized for color comparison of the pool water. The coloration standard is in PPM for matching analysis. It is suggested to store the test kit in a cool, dry area and change the liquid reagents at least every 6 months. This D.P.D. test kit should also measure combined chlorine, or bromine, total alkalinity pH, and calcium hardness.

pH

pH is the measurement of acidity (acid), or alkaline (base) within the pool water. It is extremely important to maintain a proper pH level in the pool, since the concentration of acid directly affects bather comfort and the effectiveness of any chemical added to the pool. All pool chemicals and the addition of fresh make-up water will effect the pool pH in some way.

The pH must be maintained between 7.2 and 8.0, with the ideal range of 7.2 – 7.8.

Tests for the pH should be made at least daily and then adjusted accordingly. The addition of chemicals to balance the pH should always be done without bathers in the pool. **Read the label and follow the directions on the label.**

pH CHART

INCREASINGLY ACIDIC ←	NEUTRAL	INCREASINGLY BASIC →
0 1 2 3 4	5 6 7 8 9	10 11 12 13 14
CORROSIVE TO POOL EQUIPMENT	NEUTRAL	SCALE FORMING, ALGAE GROWTH
CHLORINE EFFICIENCY IS LOST	MAXIMUM USE OF CHLORINE	CHLORINE LESS EFFECTIVE
IRRITATING TO EYES	BATHER COMFORT ZONE	IRRITATING TO SKIN
6.8 7.0 7.2	7.4 7.6 7.8	8.0 8.2

Superchlorination

During conditions of high bather load and generally lower pH, chlorine and bromine readily combine with nitrogen wastes (sweat, urine, body oils) present in the pool water instead of acting as a disinfectant to destroy harmful bacteria. The new nitrogen compounds formed are called *chloramines,* which now cause unpleasant, chlorine-like odors and eye irritations. Large dosages of chlorine based products may be then necessary to remove these unwanted chemicals from the pool.

The D.P.D. test kit is used to measure the *combined chlorine* level in the pool. If the difference between the *total* and the *free available* chlorine is greater than 0.5 ppm, then the chloramines must be removed. A dosage of at least TEN (10) times this difference (greater than 0.5 ppm), needs to be added to the pool water.

Generally, 1 gallon of liquid chlorine added to 10,000 gallons of pool water will raise the chlorine residual 10 ppm to eliminate the chloramines.

For a period of at least 12 hours, leave the automatic chlorine or bromine feeder off allowing "superchlorination" to take place. After 24 hours the chlorine residual will have dropped down to a safe level for swimming. The excess chlorine will dissipate during this time.

Clarity

If the pool water is cloudy where you cannot clearly see the outline of the bottom main drain, from the shallow end of the pool deck, the pool should be closed for use until the water clears. This could take several hours to several days.

Temperature

When a pool heater is utilized, the water temperature for pools should be 76° to 86°F. Spa pool water is to be heated no higher than 104°F. A caution sign shall be posted at the spa pool stating water temperature. Because of this elevated temperature, children under 6 years of age should not be allowed in the spa pool.

Bacteriological Analysis

At least one water sample, per pool, must be collected weekly for bacteriological analysis. Samples are collected in specially prepared sample bottles supplied by the local health department (in some locations from the Michigan Department of Public Health Laboratory). Upon sampling, complete the included form and return the sample to the laboratory within 12 hours. The swimming pool owner or operator is responsible for the collection and delivery of the samples. An analysis fee is charged per sample. Record sample results on the monthly operational report, submitted to the local health department.

BASIC POOL EQUIPMENT

You must know the basic purpose for each component of your pool filtration system. Recirculation, filtration, disinfection, and other equipment are all used to maintain pool water quality and clarity.

Recirculation Equipment

The pump is the heart of the pool system causing water to flow at the desired rate. Skimmers or gutters remove the contaminated pool water from the pool. Main drain(s) remove any bottom debris from the pool floor. Piping carries the water to and from the pool. Wall or floor inlets uniformly return the chemically treated, filtered water to the pool.

Filtration

The filter removes dirt and debris from the water, before returning the water to the pool(s). There are three general types of filters:

- Sand
- Diatomaceous Earth
- Cartridge

Dirt particles get capture in the spaces between the sand, D.E. material, or fabric of the cartridge filters. For this reason the filters need to be periodically cleaned to remove the debris.

Equipment Maintenance

The pool operator must maintain all mechanical equipment in good repair and operating condition. When equipment is not operating properly, the pool must be CLOSED until all necessary repairs have been completed. You are advised to notify the Health Department when major repairs or changes are necessary.

POOL VOLUME

The volume of your pool is the most important number you need to know. Volume is the number of gallons of water in the pool. The size of the pump, filter, chemical feeder, heater, and other related equipment are ALL based on pool volume. The addition of pool chemicals is also dependent on pool volume.

Calculating Your Pool Volume

*Measure the length and width in feet. Determine the average depth in feet. For rectangular pools:

Length × Width × Average Depth × 7.5 = Pool Volume in Gallons

For round or oval pools:

Diameter × Diameter × Average Depth × 5.9 = Pool Volume in Gallons

For other shaped pools:

Surface Area 2 Average Depth × 7.5 = Pool Volume in Gallons

FLOW RATE

The pool flow rate is the amount of water that flows through the pool in a measure time period. It is measured in gallons per minute (gpm). The size of most pool equipment is dependent on the flow rate, therefore you must know how to calculate the rate.

The required flow rate for pools with skimmers is calculated from the number of skimmers multiplied by 38 gpm.

Pool Volume ÷ Turnover Period × 60 = Flow Rate in Gal/Min.

Calculating your pool flow rate:

Formula:

$$\text{Flow Rate (F.R.)} = \frac{\text{Pool Volume (gallons)}}{\text{Turnover Time} \times 60 \text{ (min./hour)}}$$
(in hours)

Example:

$$\text{F.R.} = \frac{36{,}000 \text{ (gallons)}.}{6 \text{ (hours)} \times 60 \text{ (minutes)}}$$

$$\text{F.R.} = \frac{36{,}000}{360}$$

F.R. = 100 gallons per minute

Required turnover rate for pools:

Swimming pools .... 8 Hours or less (6 hours preferred)
Wading pool .... 2 Hours or less
Spa pools .... 1 Hour or less (1/2 hour preferred)

Other Equipment

Valves are used to route the pool water and adjust the flow rate to the different parts of the pool. The flow meter is used to measure the flow rate by monitoring the actual flow rate in the system. Pressure gauges measure the incoming and outgoing pressure of the filter. These all assist in monitoring the cleanliness of the pool water.

Operational Reports

A monthly operational report for each pool must be completed and submitted to the County Health Department (or local health department) at the end of the month. Forms are available from the local health department. Record water chemistry and other pertinent information on these forms.

BATHER SANITATION/PERSONAL HYGIENE

A person or persons who have infectious or communicable disease, or condition such as a cold, flu, skin eruptions, open blister or inflamed eyes should be excluded from the swimming pool. If the person mentioned above can furnish a physician's written statement stating that the condition is not communicable, then they would be allowed to use the swimming pool. When the owner or operator allows food or drink and associated articles in a swimming pool enclosure, the owner or operator shall provide poolside control to maintain safe and sanitary conditions. Food preparation is not permitted within the swimming pool enclosure. A sign stating the above shall be prominently displayed at a swimming pool.

Consumption of alcoholic beverages in a spa pool is not permitted. A sign warning against consumption of alcoholic beverages in a spa pool shall be prominently displayed. A foot spray using potable water shall be provided at swimming pool enclosure entrance for its users (except if swimmers are routed through a shower room). The shower spray head should be 18" – 24" high as to spray bathers from knees to feet. The water should then drain to waste so it does not pond.

A person who uses a swimming pool shall first take a cleansing shower in the nude, using warm water and soap, then thoroughly rising off all the suds before entering the swimming pool enclosure. The apparel worn in a swimming pool, spa pool or wading pool shall be clean not frayed. A sign is suggested for posting where swimmers can see it and observe this rule.

FOR ADDITIONAL INFORMATION AND CLARIFICATION, IT IS SUGGESTED TO CONTACT YOUR LOCAL MDEQ (see appendix J).

PUBLIC SWIMMING POOLS
Act 368 Of the Public Acts of 1978 and Rules

PREFACE

The statutes and administrative rules in this publication are reprinted from the test of the Michigan Compiled Laws, supplemented through the 1982 Regular Session of the Michigan Legislature and Act No. 171 of the Public Acts of 1983, and from the text of the Michigan Administrative Code, supplemented through October 1, 1983, and are made available to the Department of Public Health pursuant to §§ 4.321 and 24.258 of the Michigan Compiled Laws.

Materials in boldface type, particularly catchlines and annotations to the statutes, are not part of the statutes as enacted by the Legislature.

Request for additional copies of this publication should be directed to the Department of Public Health, Bureau of Environmental and Occupational Health, 3423 North Logan Street, P.O. Box 30195, Lansing,, Michigan 48909.

TABLE OF CONTENTS

PART 3. OPERATION AND USE

PUBLIC HEALTH CODE (EXCERPTS)

Act 368, 1978; Eff. Sept 30

AN ACT to protect and promote the public health; to codify, revise, consolidate, classify, and add to the laws relating to public health; to provide for the prevention and control of diseases and disabilities; to provide for the classification, administration, regulation, financing, and maintenance of personal, environmental, and other health services and activities; to create or continue, and prescribe the posers and duties of, departments, boards, commissions, councils, committees, task forces, and other agencies; to prescribe the powers and duties of governmental entities and officials; to regulate occupation, facilities, and agencies affecting the public health; to promote the efficient and economical delivery of health care services, to provide for the appropriate utilization of health care facilities and services, and to provide for the closure of hospitals or consolidation of hospitals or services; to provide for the collection and use of data and information; to provide for the transfer of property; to provide certain immunity from liability; to provide for penalties and remedies; and to repeal certain acts and parts of acts.

The People of the State of Michigan enact:

PART 125. CAMPGROUNDS, SWIMMING AREAS, AND SWIMMERS' INCH

333.12521 Definition used in §§ 333.12521 to 333.12534.

Sec. 12521. As used in section 12521 to 12534:

(a) "Person" means a person as defined in section 1106 or a governmental entity.

(b) "Public swimming pool" means an artificial body of water used collectively by a number of individuals primarily for the purpose of swimming, wading, recreation, or instruction and includes related equipment, structures, areas, and enclosures intended for the use of individuals using or operating the swimming pool such as equipment, dressing, locker, shower, and toilet rooms. Public swimming pools include those which are for parks, schools, motels, camps, resorts, apartments, clubs, hotels, mobile home parks, subdivisions, and the like. A pool or portable pool located on the same premises with a 1-, 2-, 3-, or natural bathing area such as a stream, lake, river, or man-made lake, an exhibitor's swimming pool built as a model at the site of the seller and in which swimming by the public is not permitted, or a pool serving not more than 4 motel units is not a public swimming pool.

History: 1978. Act 368. Eff. Sept. 30, 1978.

333.12522 Public swimming pool; review of design, construction, and operation; rules.

Sec. 12522. (1) The department shall review the design, construction, and operation of public swimming pools to protect the public health, prevent the spread of disease, and prevent accidents or premature deaths.

(2) The department shall promulgate rules to carry out sections 12521 to 12534.

History: 1978, Act 368, Eff. Sept. 30, 1978.

333.12523 Construction and operation of public swim-- ming pools; supervisory and visitorial power; control.

Sec. 12523. The department has supervisory and visitorial power and control as limited in sections 12521 to 12534 over persons engaged in the construction ad operation of public swimming pools.

History: 1978, Act 368, Eff. Sept. 30, 1978.

333.12524 Public swimming pools; periodic inspections; right of entry.

Sec. 12524. (1) The department, its agents or representatives, or representatives of a designated local health department shall make periodic inspections of public swimming pools.

(2) The department, its agents or representatives, or representatives of a designated local health department may enter upon the swimming pool premises and other property of a person at all reasonable times for the purpose of inspecting the swimming pool and carrying out the authority vested in the department under sections 12521 to 12534.

History: 1978, Act 368, Eff. Sept. 30, 1978.

333.12525 Construction or modification of public swimming pool; review and approval of plans and specifications; free; permit; responsibility of applicant or owner; nuisance or hazard to health or safety; description of swimming pool system and auxiliary structures.

Sec. 12525. (1) A person intending to construct a public swimming pool or intending to modify an existing public swimming pool shall submit plans and specifications for the proposed installation accompanied by a fee specified in section 12527a to the department for review and approval and shall secure a permit for the construction. A person shall not start or engage in the construction of a public swimming pool or modify an existing public swimming pool until the permit for the construction is issued by the department.

](2) Sections 12521 to 12534 or an action of the department shall not relieve the applicant or owner of a public swimming pool from responsibility for securing a building permit or complying with applicable local codes, regulations, or ordinances not in conflict with sections 12521 to 12534. Compliance with an approved plan does not authorize the owner constructing or operating a public swimming pool to create or maintain a nuisance or a hazard to health or safety.

](3) Plans and specifications submitted for the purpose of obtaining a construction permit shall include a true description of the entire swimming pool system and auxiliary structures or parts thereof as proposed to be constructed and operated.

History: 1978, Act 368, Eff. Sept. 30, 1978.

333.12526 Examination of plans and specifications; determination; issuance of permit; notice of deficiencies; resubmission of documents; duration of permit; written approval of change.

Sec. 12526. (1) The department shall examine the plans and specifications and determine whether the swimming pool facilities, if constructed in accordance therewith,, are or would be sufficient and adequate to protect the public health and safety. If the plans and specifications are approved, the department shall issue a permit for construction. If the plans and specifications are not approved, the department shall notify the applicant or the applicant's representative of the deficiencies. The applicant may have the plans and specifications amended to remedy the deficiencies and resubmit the documents, without additional fee, for further consideration.

(2) A construction permit shall be valid for not more than 2 years after the date of issuance unless a written time extension is granted by the department.

(3) Each public swimming pool shall be constructed or modified in accordance with the approved plans and specifications unless written approval of a change is granted by the department.

History: 1978, Act 368, Eff. Sept. 30, 1978.

333.12527 Operation permit required; fee; display; expiration; renewal; replacement.

Sec. 12527. (1) A public swimming pool shall not be operated without an operation permit.

(2) A person engaged in the operation of a public swimming pool shall obtain a permit to operate the swimming pool from the department and shall pay an initial operation permit fee as specified in section 12527a.

(3) An operation permit shall be displayed by the owner in a conspicuous place on the premises.

(4) An operation permit shall expire December 31 of each year.

(5) An operation permit shall be renewed upon receipt of a proper application, an annual renewal fee as specified in section 12527a, and evidence that the public swimming pool is being operated and maintained in accordance with section 12521 to 12534 and the applicable rules and regulations.

(6) An operation permit shall not be transferred to another person but it may be replaced by another operation permit upon receipt of a proper application and the fee specified in section 12527a.

History: 1978, Act 368, Eff. Sept. 30, 1978.

333.12527a Fees.

Sec. 12527a. The fees related to swimming pool regulation under this part are as follows:

(a) Construction permit fee for a swimming pool, except as provided in subdivision (b) $200.00

(b) Construction permit fee for each additional swimming pool of the same design, constructed at the same site, and at the same time $100.00

(c) Initial operation permit fee for a swimming pool, except as provided in subdivision (d) $200.00

(d) Initial operation permit fee for each additional swimming pool of the same design, constructed at the same site, and at the same time $100.00

(e) Renewal operation permit fee, to March 31 . .$50.00

(f) Renewal operation permit fee, after March 31 $75.00

(g) Renewal operation permit fee, after lapse of 1 licensure year without an operation permit $100.00

(h) Replacement operation fee for transfer to another person $50.00

History: 1978, Act 368, Eff. Sept. 30, 1978.

333.12528 Denial of operation permit; grounds; notice; failure to correct deficiencies or noncomplying items.

Sec. 12528. If upon investigation, the department or designated local health department finds that a public swimming pool was not constructed or modified in accordance with the approved plans and specifications, the department or designated local health department shall give written notice to the applicant that the operation permit will not be issued, citing the deficiencies or noncomplying items that constitute the reasons for not issuing the operation permit. An applicant who fails to correct the deficiencies or noncomplying items shall be denied an operation permit.

History: 1978, Act 368, Eff. Sept. 30, 1978.

333.12529 Revocation of operation permit; grounds; hearing; reissuance.

Sec. 12529. The department may revoke the operation permit upon a finding that the pool is not being operated or maintained in accordance with sections 12521 to 12534 or the rules. A person aggrieved by a decision of the department shall be granted a hearing. A permit that has been revoked shall be reissued only when the department determines the deficiencies are corrected.

History: 1978, Act 368, Eff. Sept. 30, 1978.

333.12530 Periodic reports covering operation of public swimming pools.

Sec. 12530. The department shall provide for a system of periodic reports covering the operation of the public swimming pool so that the department may readily determine compliance with sections 12521 to 12534 and the rules.

History: 1978, Act 368, Eff. Sept. 30, 1978.

333.12531 Ordering owner or operator to prohibit use of swimming pool.

Sec. 12531. If the department, its agent or representative, or a representative of a designated local health department considers that conditions warrant prompt closing of a swimming pool until sections 12521 to 12534 and the rules are complied with for the protection of the public health and safety, the department or designated local health department may order the owner or operator of the swimming pool to prohibit an individual from using it until corrections are made to protect adequately the public health and safety.

History: 1978, Act 368, Eff. Sept. 30, 1978.

333.12532 Payments to local health departments.

Sec. 12532. (1) The department may approve payments for each swimming pool granted an initial operation permit and each renewal operation permit to a designated local health department when the fees are collected by the state from the local health department's respective area, as follows:

(a) Initial operation permit for a swimming pool, except as provided in subdivision (b) $100.00

(b) Initial operation permit for each additional swimming pool of the same design, constructed at the same site, and at the same time $ 50.00

(c) Renewal operation permit, to March 31 $ 30.00

(d) Renewal operation permit, after March 31 $ 45.00

(e) Renewal operation permit, after lapse of 1 licensure year without an operation permit $70.00

(2) the sate treasurer shall make the payments upon receipt of approval from the department.

History: 1978, Act 368, Eff. Sept. 30, 1978; – AM. 1980, Act 522. Imd. Eff. Jan 26, 1981; – Am. 1985, Act 19.

333.12533 Violation as misdemeanor; each day of violation as separate violation; prosecution.

Sec. 12533. A person who violates sections 12521 to 12531 or a rule promulgated under those sections is guilty of a misdemeanor. Each day upon which a violation occurs is a separate violation. The attorney general or local prosecuting attorney shall be responsible for prosecuting a person who violates sections 12521 to 12531.

History: 1978, Act 368, Eff. Sept. 30, 1978.

333.12534 Action for injunction or other process.

Sec. 12534. Notwithstanding the existence and pursuit of any other remedy, the department, its agent or representative, or a representative of a designated local health department may maintain an action in the name of the state for injunction or other process against a person to restrain or prevent the construction or modification of a public swimming pool without a construction permit, or the operation of a public swimming pool without an operation permit, or in a manner contrary to law.

History: 1978, Act 368, Eff. Sept. 30, 1978.

ADMINISTRATIVE RULES

DEPARTMENT OF PUBLIC HEALTH

ENVIRONMENTAL AND OCCUPATIONAL HEALTH SERVICES ADMINISTRATION

Public Swimming Pools

(By authority conferred on the department of public health by section 2226, 2233 and 12522 of Act No. 368 of the Public Acts of 1978, as amended, being §§ 333.2226, 333.2233, and 333.12522 of the Michigan Compiled Laws)

Part 1. General Provisions

R 325.2111 Definitions.

Rule 1. As used in these rules:

(a) "Code" means Act No. 368 of the Public Acts of 1978, as amended, being § 333.1101 et seq. of the Michigan Compiled Laws.

(b) "Department" means the Michigan department of public health.

(c) "Modification" means any alteration of a swimming pool tank, water treatment equipment, water circulation system, enclosure, or building or appurtenances, except for normal maintenance, repairs, or equipment replacement.

(d) "Spa pool" means a swimming pool which is designed for sitting in and is not intended for swimming. A spa pool may have agitation of the water and may have water temperatures different than those normally in pools for swimming.

(e) "Swimming pool" means a public swimming pool as defined in section 12521 of the code. Some examples of swimming pools are cold plunge pools, diving pools, hot tubs, scuba diving pools, slide pools, spa pools, training tanks, wading pools, water slides, wave pools, and other special purpose pools.

(f) "Wading pool" means a swimming pool which is shallow enough throughout for wading.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R 325.2113 Plans and specifications.

Rule 3. (1) Plans and specifications submitted for a construction permit for a new swimming pool or modification of an existing swimming pool shall meet all of the following requirements:

(a) Be prepared by, and bear the seal of, a professional engineer or architect licensed in this state. This subdivision does not apply to a new swimming pool or modification costing less than $15,000.00.

(b) Be submitted in triplicate to the department and be accompanied by completed construction permit application forms as prescribed and provided by the department.

(c) Be accompanied by the free prescribed by the code, payable to: "State of Michigan."

(2) Plans and specifications submitted for a construction permit for a new swimming pool shall meet both of the following requirements:

(a) Include a plot plan showing all of the following:

(i) North point.

(ii) Property boundaries.

(iii) Adjacent streets.

(iv) Pertinent buildings on the site.

(v) Pertinent site grades.

(vi) Utility lines.

(vii) The swimming pool and related deck areas.

(b) Show, in detail, all of the following as appropriate:

(i) The swimming pool tank and related facilities.

(ii) The swimming pool water treatment and recirculation equipment and piping.

(iii) Dressing rooms.

(iv) Locker rooms.

(v) Shower rooms.

(vi) Toilet rooms.

(vii) Storage rooms.

(viii) Offices.

(ix) Mechanical equipment rooms.

(x) Source of water supply.

(xi) Wastewater disposal facilities.

(3) Plans and specification submitted for a construction permit for modification of an existing swimming pool shall show the proposed modifications and the pertinent existing facilities.

(4) When plans and specifications are submitted to the department, 1 set shall be submitted to the designated local health department.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R 325.2114 Variances.

Rule 4. (1) A swimming pool shall comply with the requirements of part 2 of these rules, except that the department may grant a variance where the department determines that strict compliance will cause unusual practical difficulties and hardships or will conflict with a special purpose intended for the pool and that the variance will not seriously affect the safe and healthful operation of the swimming pool.

(2) For an equipment item, material, design feature, or construction method not specifically covered in part 2 of these rules, the department may require adequate proof that the item, material, feature, or method will perform the intended function so as to produce a safe and healthful swimming pool.

(3) A swimming pool which is not in compliance with the specific provisions of these rules on their effective date, but which is in compliance with the rules in effect when it was installed and which is in good repair, is exempt from those provisions of these rules which require major structural or mechanical changes until pertinent modifications are made. When a swimming pool is modified, the portion modified shall be brought into compliance with applicable provisions of these rules, unless a variance is granted by the department.

(4) Subrule (3) of this rule does not preclude the department from requiring changes where necessary to correct a threat to public health or an unsafe condition associated with a swimming pool.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R 325.2115 Operation permit application.

Rule 5. An application for an initial or renewal operation permit or for replacement of an operation permit shall be made to the department on the forms prescribed and provided by the department. An application shall be accompanied by the fee prescribed by the code, payable to: "State of Michigan."

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R 325.2116 Violations.

Rule 6. (1) When a representative of the department or of a designated local health department inspects a swimming pool and finds a violation of the code or these rules, the department representative shall issue a written notice of noncompliance to the owner or the owner's representative which specifies the corrective action to be taken and shall allow an appropriate time period for correction.

(2) If construction is being performed contrary to the code or these rules, the department representative may issue a written stop-work order. If a stop-work order is issued, the construction will be stopped, except for such work as is necessary to remove a violation or unsafe condition, until compliance is achieved.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R 325.2117 Closing of swimming pools; reasons.

Rule 7. A representative of the department or of a designated local health department may order the owner or operator of a swimming pool to prohibit any person from using it, until correction, for any of the following reasons:

(a) A condition of the swimming pool equipment, structure, area, or enclosure which jeopardizes the health or safety of the persons using or operating it.

(b) The lack of properly functioning equipment or proper material for recirculating, treating, or testing the swimming pool water.

(c) The lack of supervisory personnel, as required by R 325.2197, or lifeguards, as required by R 325.2198.

(d) The presence of a pollutant or of a hazardous object or substance in the swimming pool.

(e) Failure to meet a water quality standard prescribed by R 325.2194 or R 325.2195.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R 325.2118 Closing of swimming pools; procedure.

Rule 8. (1) When a representative of the department or of a designated local health department orders the owner or the operator of a swimming pool to prohibit any person from using it, the department representative shall issue a written order to the swimming pool owner or operator or owner's representative stating that the swimming pool shall be closed immediately and specifying corrective action to be taken. The order shall be served upon the owner, operator, owner's representative, or person in charge of the swimming pool. The person on whom the order is served shall close the swimming pool immediately and shall prohibit any person from using it. The order may require the owner or operator or owner's representative to post 1 or more signs to inform any person that the swimming pool is closed until further notice.

(2) After the specified corrective action has been taken, the owner or operator or owner's representative shall notify the department or the designated local health department that the swimming pool is ready for reinspection.

(3) If upon reinspection the corrective action has been taken, the swimming pool may be opened for use.

(4) If upon reinspection the corrective action has not been taken, the swimming pool shall continue to be kept closed and out of use until corrective action has been taken and the swimming pool has been reinspected.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R 325.2118a Reopening inspections.

Rule 8a. (1) Prior to the reopening of a swimming pool for seasonal use, the swimming pool facilities shall be prepared for use. The swimming pool water shall be filtered and disinfected to meet the water quality standards prescribed by R 325.2194. The owner shall notify the department or designated local health department when the swimming pool is ready for use.

(2) A representative of the department or a designated local health department may inspect the facilities prior to authorizing seasonal use of a swimming pool.

(3) If a reopening inspection reveals a condition listed in R 325.2117, a representative of the department or a designated local health department may order the owner or operator of the swimming pool to prohibit any individual from using it until adequate corrections are made.

History: 1979 ACS 15, Eff. July 21, 1983.

R 325.2118b Swimming pools not in use.

Rule 8b. A swimming pool which is not in use or for which no operation permit is in effect shall be maintained by the owner in a condition which prevents its creating a hazard to health or safety.

History: 1979 ACS 15, Eff. July 21, 1983.

R 325.2119 Rescission.

Rule 9. The rules entitled "Construction and Alteration of Public Swimming Pools," being R 325.391 to R 325.395 of the Michigan Administrative Code and appearing on page 2254 of the 1954 volume of the Code, and the rules entitled "Operation and Use of Public Swimming Pools." Being R 325.401 to R 325.406 of the Michigan Administrative Code and appearing on pages 2254 and 2255 of the 1954 volume of the Code, are rescinded.

History: 1954 ACS 67. Eff. Mar. 24, 1971.

Part 2. CONSTRUCTION

R 325.2121 Sites.

Rule 21. A swimming pool shall be located at a site which meets all of the following requirements:

(a) Has pertinent utilities available.

(b) Is not detrimental to safe access or to the safe and healthful use of the swimming pool.

(c) Is accessible by vehicles.

(d) Has drainage adequate to prevent flooding, damage, and a nuisance.

(e) Is not detrimental to the proper operation and maintenance of the swimming pool.

(f) Avoids pollution of the swimming pool.

(g) Enables the swimming pool to be safely emptied when necessary.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R 325.2122 Construction shapes, materials, surfaces and loads.

Rule 22. (1) A swimming pool and appurtenances shall be shaped and arranged so that the maintenance of safe and sanitary conditions and the recirculation of the water are not impaired. Nothing shall extend into or above a swimming pool tank so as to create a safety hazard.

(2) A swimming pool and appurtenances shall be constructed of materials which are inert, nontoxic to humans, impervious, durable, and strong enough to withstand structural stresses.

(3) A finished surface of a swimming pool wall or floor shall be smooth, without cracks or open joints, slip-resistant, easily cleanable, nonabsorbent, and light colored, except that a dark marking may be inserted against a light background.

(4) A swimming pool tank shall be designed and constructed to withstand all anticipated loadings for both full and empty conditions. If a swimming pool tank is subject to external hydrostatic pressure, means to relieve that pressure shall be provided.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R 325.2123 Walls and floors.

Rule 23. (1) Where the water depth is 6 feet or less, a swimming pool wall shall be vertical or slope uniformly at not more than 1 foot horizontally in 5 feet vertically. Where the water depth is more than 6 feet, the wall shall be vertical or slope uniformly at not more than 1 foot horizontally in 5 feet vertically to a water depth of not less than 6 feet, or to a water depth of not less than 3 feet and then curve to the floor with a radius not greater than the difference between the depth at that point and the depth at the point of curvature, or to a water depth of not less than 3 feet and then slope to the floor at not more than 45 degrees from vertical.

(2) A ledge shall not protrude into a swimming pool unless it is essential for support of the upper wall. If a ledge is provided, it shall not exceed 4 inches in width, shall slope downward from the wall, and shall be designed to prevent its use as a walkway.

(3) The junction between a swimming pool wall and the floor shall be coved with a radius of not less than 1/2 inch. Where the water depth is 6 feet or less, the cove radius shall not exceed 8 inches.

(4) The swimming pool floor shall slope toward the main outlets.

(5) Where the water depth is 4 feet or less, the swimming pool floor shall slope uniformly at not more than 1 foot vertically in 12 feet horizontally. Where the water depth is between 4 feet and 6 feet, the floor shall slope not more than 1 foot vertically in 3 feet horizontally.

(6) A swimming pool, other than a spa pool or a wading pool, shall have a continuous handhold which is not more than 12 inches above the water surface. A spa pool shall have handholds which are not more than 4 feet apart and not more than 12 inches above the water surface.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R 325.2125 Water supplies.

Rule 25. (1) The water serving a swimming pool and all plumbing fixtures shall be obtained from a type I public water supply if available. If a type 1 water supply is not available, water shall be obtained from a supply which meets the requirements for type II public water supplies. The water supply types are those classified by R 325.10502.

(2) The supply of water shall be adequate for service to all plumbing fixtures and for furnishing to the swimming pool not less than 1 gallon per minute per 1,500 gallons of the swimming pool volume. Water at a temperature of not less than 90 degrees Fahrenheit shall be supplied to each required shower and lavatory.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R 325.2126 Water supply backflow.

Rule 26. A potable water supply system serving a swimming pool and all plumbing fixtures shall be protected against backflow. Potable water introduced into the swimming pool or recirculation system shall be supplied through permanent piping and either of the following:

(a) An acceptable air gap consisting of an unobstructed vertical distance through the atmosphere of not less than 2 diameters of the water supply pipe between the lowest free-flowing discharge of the water supply pipe and the overflow level of the receiving tank or vessel.

(b) An approved backflow preventer installation consisting of a reduced pressure zone backflow preventer which has been accepted by the department and the state board of plumbing and which is installed where it is readily accessible for inspection and maintenance, is not subject to flooding, and has no direct connection between the drain port and a wastewater system.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R 325.2127 Wastewater disposal systems

Rule 27. (1) A swimming pool shall have a wastewater disposal system which shall serve the entire swimming pool facility. The wastewater disposal system shall have sufficient capacity to prevent flooding during the swimming pool filter cleaning cycle and during draining of the swimming pool.

(2) Wastewater from a swimming pool shall be discharged to a public sewerage system if it is available. If a public sewerage system is not available, the substitute system shall dispose of the wastewater without creating a threat to public health or safety, a nuisance, or unlawful pollution of the waters of the state.

(3) A swimming pool and its recirculation system shall be protected against backflow from a wastewater disposal system. A pipe from the swimming pool or its recirculation system to a sewer shall discharge through an air gap of not less than 2 pipe diameters, unless the elimination of the air gap is warranted.

(4) The wastewater disposal system shall enable emptying of the swimming pool.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R 325.2128 Enclosures.

Rule 28. (1) A swimming pool shall be enclosed completely by a wall, fence, or other protective enclosure. The entire enclosure, including doors and gates, shall be not less than 4 feet high as measured on the outside, shall not provide ready footing for climbing, and shall prevent passage through it and under it.

(2) The enclosure shall have at least 1 entrance. Each entrance shall have a door or gate with a self-closer, a latch, and a lock. An entrance for bathers shall lead to the shallowest area of the swimming pool.

(3) Two or more swimming pools may be within a single enclosure, except that a wading pool shall be enclosed separately.

(4) An entrance to a wading pool shall be arranged to prevent traffic directly between it and a swimming pool. An entrance shall not be provided in a common barrier between a wading pool and a swimming pool.

(5) A spectator area shall be completely separated from an area used by bathers by a barrier. A balcony shall not overhang any portion of the swimming pool water surface and shall have a continuous curb not less than 4 inches high, a suitable barrier at the outer edge, and a separate floor drainage system.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R 325.2129 Walkways and decks.

Rule 29. (1) A continuous, unobstructed walkway not less than 4 feet wide shall extend completely around a swimming pool other than a spa pool. A continuous, unobstructed walkway not less than 4 feet wide shall be provided along not less than 10 feet of the perimeter of a spa pool at a means of egress from it. A walkway between 2 swimming pool shall be not less than 5 feet wide, except that a common wall which is not more than 12 feet long and which is designed to prevent walking thereon may separate a spa pool and another swimming pool. An unobstructed walkway not less than 3 feet wide walk be provided at the side and behind a piece of diving or deck equipment.

(2) The entire deck area between a swimming pool and a swimming pool enclosure shall be paved or otherwise constructed and maintained to prevent surface drainage, dirt, and other deleterious material from being carried into the swimming pool.

(3) The walkway and the deck shall be slip-resistant, easily cleanable, and nonabsorbent. Walkway or deck covering material shall be slip-resistant and easily cleanable, shall not support the growth of microorganisms, shall not entrap water, and shall not adversely affect drainage of the surface. A junction between a walkway or deck and a wall shall be coved.

(4) The deck shall be constructed so that water will not pool. The deck shall slope to drains or other unobstructed points of disposal. A walkway shall not slope to the swimming pool, and a coping or other means to prevent water flow from a walkway into the swimming pool shall be provided. A deck drain shall discharge to waste only.

(5) An opening in the deck or walkway within the swimming pool enclosure shall have a locking-type cover which is flush with the deck or walkway surface.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R 325.2131 Drinking fountains.

Rule 31. A drinking fountain shall be provided at a swimming pool. A drinking foutain shall be the angle jet type and shall be located where it is readily accessible to the bathers and is not a safety hazard. A drinking fountain shall not be located in a toilet area or shower area.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R 325.2132 Water depths; depth markings; lifelines.

Rule 32. (1) In a swimming pool smaller than 800 square feet in water surface area, with shallow area for walking or standing, the water depth shall not exceed 5.0 feet. The water depth in a wadding pool shall not exceed 1.5 feet. The water depth in a spa pool shall not exceed 4.0 feet.

(2) The depth of water in a swimming pool shall be plainly marked on the deck next to the swimming pool and above the water surface on the swimming pool wall, if possible. Depth markers shall be provided at the maximum and the minimum depths, at a change in the floor slope between shallow and deeper areas, at other critical points, and at intermediate points not more than 25 feet apart measured peripherally. A depth marker shall be at each side and at each end of the swimming pool. A marker shall be in legible numerals not less than 4 inches high and of a color contrasting with the background. Where the water depth is less than 5.0 feet at a swimming pool other than a spa pool or a wading pool, the words "no diving" shall be placed between the depth markers on the deck. The words shall be in legible letters not less than 4 inches high and of a color contrasting with the background.

(3) A change of floor slope between a shallow area and a deeper area, or the 5.0 foot water depth if there is no change in slope at a water depth less than 5.0 feet and if there are water depths of more than 5.0 feet, shall be clearly designated with a lifeline. The lifeline shall have floats and have anchors in both side walls near the water level.

(4) Nothing in this rule shall preclude the use of a swimming pool for competitive swimming.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R 325.2133 Diving areas and facilities.

Rule 33. (1) A diving facility shall not be installed without prior approval from the department. A diving facility higher than 3 meters above the water shall not be installed, except with special approval, in writing, from the department.

(2) A diving area shall conform to table 1 of this rule.

(3) Table 1 reads as follows (see below):

TABLE 1

Diving Areas

		Minimum Distances					
Maximum Height of Diving Board Above Water	Maximum Diving Board Length	Water Depth at End of Diving Board	Distance and Depth of Water Ahead of Diving Board		From End Of Diving Board Back to End Wall	From Diving Board to Wall Ahead	From Center of Diving Board to Side Wall
			Distance	Depth			
0.5 meter	10 feet	7 feet	*	8 feet	2.0 feet	26 feet	10 feet
1 meter	16 feet	11 feet	20 feet	10.75 feet	5.0 feet	29 feet	10 feet
3 meters	16 feet	12 feet	20 feet	11.75 feet	5.0 feet	34 feet	12 feet

*From 1 foot to 12 feet ahead of diving board

(4) The pool floor shall slope not more than 1 foot vertically in 2 feet horizontally beyond a distance ahead of a diving board of not less than 20 feet, or not less than 12 feet if the diving board height is 0.5 meters or less.

(5) The centerline of a diving board shall be not less than 10 feet from the centerline of an adjacent diving board.

(6) Diving equipment shall be installed only in conformity with this rule and the equipment manufacturer's recommendations.

(7) Unobstructed vertical clearance above a diving board of not less than 12 feet, or not less than 16 feet ahead of, the front end of the diving board and for 8 feet on each side of the centerline of the diving board. Any reduction in vertical clearance from 16 feet ahead of the diving board shall slope not more than 30 degrees from horizontal for the first 8 feet horizontally.

(8) A diving board, platform, and appurtenances shall be constructed to ensure stability and safely carry the maximum anticipated loads. The stairway shall be corrosion-resistant, easily cleanable, nonabsorbent, and slip-resistant. A diving stand or platform more than 1 meter above the water shall have handholds on both sides of the stairway or ladder and shall have guard railings which have intermediate rails and which extend to a position above the edge of the water.

(9) The safety of swimmers and divers shall be considered in the location and orientation of diving facilities. A diving board shall not extend toward another diving board.

(10) If a swimming pool does not comply with the requirements of this rule, and if the department has issued a correction order to remedy an unsafe condition under R 325.2114(4), a diving facility shall not be installed or maintained and a sign warning against diving, in legible letters not less than 4 inches high, shall be prominently displayed.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R 325.2134 Ladders and stairways.

Rule 34. (1) A swimming pool which is not a wading pool or a spa pool and which is less than 30 feet wide shall have at least 1 means of egress at each end. A swimming pool which is not a wading pool and which is 30 or more feet wide shall have not less than 2 means of egress at each end, located at opposite sides. A spa pool shall have at least 1 means of egress. A means of egress shall consist of a ladder, stairway, or ramp. The distance from any point in a swimming pool to a means of egress shall not exceed 50 feet. At least 1 ladder per diving board shall be provided in a diving area.

(2) A swimming pool ladder shall be corrosion-resistant and sturdy and shall have slip-resistant treads, side rails extending over the deck, and not more than 6 inches of clearance to the swimming pool wall. A recessed ladder shall have stepholes which drain into the swimming pool and which are easily cleanable and shall have a grab rail at each side, above the deck.

(3) A stairway leading into a swimming pool shall be slip-resistant and shall have uniform size treads of not less than 12 inches and uniform size risers of not more than 10 inches, except that the top tread may be wider than the others, and the risers and treads at a spa pool may be other sizes acceptable to the department. A stairway shall be located where the water depth is 2.5 feet or less and where the stairway will not be a hazard to swimmers. A stairway shall have 1 sturdy handrail per 12 feet of the stairway width or fraction thereof. A handrail shall be reachable for the length of the stairway.

(4) A ramp leading into a swimming pool shall terminate where the water depth is 3.5 feet or less and where the ramp will not be a hazard to swimmers. A ramp shall be slip-resistant and shall have a sturdy handrail, reachable for the length of the ramp, along each side of the ramp.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R 325.2136 Water circulation.

Rule 36. A swimming pool shall be equipped for continuous, uniform circulation of treated water within the swimming pool tank and for continuous removal, treatment, and reuse of the water. The water recirculation and treatment system shall be adequate for recirculating and treating the entire swimming pool volume of water in 8 hours or less, in 2 hours or less for a wading pool, in 1 hour or less for a spa pool, or in less time if necessary to meet the hydraulic design requirements for the surface skimmer system.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R 325.2137 Swimming pool water piping.

Rule 37. (1) Swimming pool water piping shall be nontoxic material, durable, resistant to corrosion, and able to withstand operating pressures. Plastic pipe shall not be used for the piping from 5 feet upstream to 5 feet downstream from a water heater.

(2) The piping shall be designed to carry the required quantities of water at velocities not exceeding 5 feet per second in suction piping and 10 feet per second in pressure piping, unless greater velocities are warranted.

(3) The piping shall be protected against erosion, corrosion, mechanical damage, and other deterioration. It shall be provided with fittings necessary for disassembly of any part and shall be arranged to allow ready, safe, and proper operation and maintenance of the swimming pool facilities.

(4) Exposed piping and other conduits shall be marked with arrows showing the normal direction of water flow.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R 325.2138 Flow controls.

Rule 38. (1) A valve for regulating the rate of flow through a swimming pool shall be provided in the recirculation pump discharge piping.

(2) A rate-of-flow indicator shall be installed for a swimming pool. The indicator shall be located so that the recirculation flow rate and the filter backwash flow rate for sand-type filters will be indicated.

(3) A rate-of-flow indicator shall meet all of the following requirements:

(a) Be the proper size and design for the pipe and system on which it is installed.

(b) Have a durable scale which is graduated in gallons per minute.

(c) Have a range of readings appropriate for the flow rates.

(d) Be installed where it is readily accessible for reading and maintenance.

(e) Be installed with straight pipe upstream and downstream from the indicator to any fitting or restriction in accordance with the manufacturer's recommendations.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R. 325.2141 Inlets.

Rule 41. (1) A swimming pool water inlet system shall have inlets adequate in design, number, and location to ensure uniform distribution of treated water throughout the swimming pool.

(2) An inlet shall be equipped for flow rate adjustment. It shall not extend from the swimming pool wall or floor so as to create a hazard. An inlet fitting shall be either not less than 12 inches below the water level or not less than 6 inches below the water level and designed to direct the flow downward.

(3) One inlet per 20 lineal feet of swimming pool periphery, and more if necessary for uniform circulation of water, shall be provided.

(4) A wall inlet system shall have inlets spaced not more than 20 feet apart as measured along the swimming pool wall. A floor inlet system shall have uniformly spaced inlets not more than 20 feet apart and shall have an inlet not more than 15 feet from each wall. At least 1 inlet shall be located in each recessed stairwell or other space where water circulation might be impaired.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R 325.2142 Main outlets.

Rule 42. (1) A swimming pool shall have 2 or more main outlets in its deepest part for continuous removal of water for treatment and reuse and for emptying the pool. A main outlet shall be not less than 3 feet nor more than 20 feet from another main outlet. A main outlet shall be provided not more than 15 feet from each side wall. At a spa pool, 1 of the main outlets may be in a side wall.

(2) A main outlet opening shall be covered with a grating which is not hazardous to bathers, which is secured in place, and which is removable with tools. The grate open area shall be large enough to have water entrance velocities not exceeding 2 feet per second.

(3) Main outlet discharge piping shall be sufficient for removing water through it at a rate of not less than 100% of the swimming pool required recirculation flow rate. The piping system shall be valved to permit the adjustment of flow through it.

(4) When a pump is provided to remove water from a swimming pool tank, the outlet system shall have not less than 2 section outlets which are not less than 3 feet apart.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R 325.2143 Overflow systems.

Rule 43. (1) A swimming pool not larger than 2,400 square feet in water surface area and 32 feet or less in width shall have either a perimeter overflow system or surface skimmers. A swimming pool larger than 2,400 square feet in water surface area or more than 32 feet wide shall have a perimeter overflow system.

(2) A perimeter overflow system shall meet all of the following requirements:

(a) Extend completely around the swimming pool.

(b) Have the overflow lip at the same level throughout.

(c) Prevent entrapment of bathers' arms, legs, and feet.

(d) Permit ready inspection, cleaning, and repair.

(e) Be designed for removal of the water at a rate of not less than 100% of the required recirculation flow rate.

(f) Have provisions for discharging the water from treatment and reuse and for discharging the water to waste.

(3) A facility for reuse of the water shall provide for free discharge from the perimeter overflow system into an open tank which has a overflow that is sufficiently lower than the perimeter overflow system lip to assure continuous flow of not less than 100% of the required recirculation flow rate.

(4) A swimming pool with a perimeter overflow system shall have surge capacity of not less than 1 gallon per square foot of pool water surface area.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R 325.2144 Surface skimmers.

Rule 44. (1) A swimming pool equipped with surface skimmers shall have at least 1 surface skimmer for every 500 square feet of water surface area or fraction thereof. Additional surface skimmers shall be provided if necessary for effective skimming or to meet the hydraulic design requirements. A surface skimmer shall be located to ensure proper skimming of the entire water surface with minimum interference and minimum short-circuiting.

(2) A surface skimmer shall have an automatically adjustable weir, an easily removable and cleanable strainer basket, and a flow rate control device. If an equalizer pipe is provided, it shall have a device that will remain tightly closed under normal operating conditions. A surface skimmer shall be built into the swimming pool wall and shall not create a safety hazard.

(3) A swimming pool shall be designed for a flow of 30 gallons per minute per surface skimmer and for not more than 80% of the total swimming pool recirculation flow to be through the surface skimmer system. A surface skimmer piping system shall have a valve to permit the adjustment of flow through it.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R. 325.2145 Recirculation pumps.

Rule 45. (1) A recirculation system shall be equipped with a pump with sufficient capacity for recirculating the swimming pool volume of water within the required time period and for providing flow adequate for cleaning the filters.

(2) If the pump or suction piping is above the swimming pool water level, the pump shall be self-priming. The pump and motor shall be capable of continuous operation.

(3) A gauge to measure the pump discharge pressure and a fitting for installing a gauge to measure the pump suction pressure shall be installed.

(4) If the water is pumped from the swimming pool to the filters, a strainer shall be provided on the suction side of the pump. The strainer basket shall be corrosion-resistant, readily removable, and easily cleanable. The piping system shall be equipped with valves to permit removal of the strainer basket without water flowing through the chamber. A spare strainer basket shall be available.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R 325.2146 Water agitation systems.

Rule 46. (1) When agitation of the water in a spa pool is provided, the agitation shall be accomplished by a system separate from the water treatment and recirculation system.

(2) When an air induction system is provided, it shall prevent water backup which could cause electrical shock hazards. An air intake source shall not permit the introduction of toxic fumes or other contaminants.

History: 1979 ACS 15, Eff. July 21, 1983.

R 325.2151 Filters

Rule 51. (1) A swimming pool water treatment system shall have 1 or more filters for clarifying the water. A filter shall produce acceptable water clarity, enable easy removal of the material filtered out, and be convenient to operate and maintain. A filter shall be installed with adequate clearance and facilities for ready and safe inspection, operation, maintenance, disassembly, and repair.

(2) A filter system shall have sufficient filtration area to meet the required flow rate without exceeding the established maximum filtration rate demonstrated to produce acceptable water clarity.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R 325.2152 Sand-type filters.

Rule 52. A sand-type filter system shall be equipped for backwashing each filter at a minimum rate of 15 gallons per minute per square foot of filtration area and as recommended by the manufacturer. The backwash water shall be discharged to waste. A means for viewing backwash water clarity shall be provided.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R 325.2153 Diatomaceous earth-type filters.

Rule 53. (1) A pressure diatomaceous earth-type filter system shall have a precoat pot.

(2) A diatomaceous earth-type filter system shall discharge the filter effluent to waste or to an open tank for recirculation through the filter, and not to the swimming pool or through a closed recirculation system, during the filter precoat operation. A means for viewing the precoating effluent clarity shall be provided.

(3) A diatomaceous earth-type filter system shall effectively remove the filter-aid and the filtered-out material from the septums and the filters to waste without disassembly of the filters.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R 325.2154 Filter accessories.

Rule 54. (1) A filter system shall be equipped with valves and piping necessary to isolate the filters for maintenace and repair and to completely drain all parts of the filter system.

(2) A presure-type filter system shall be equipped with a gauge to indicate the filter influent pressure and, if the filter system is lower than the swimming pool water surface, a gauge to measure the filter effluent pressure. A pressure gauge shall be graduated in pounds per square inch, have an appropriate range of readings, and be of a size and location so it can be read easily.

(3) A pressure filter tank shall have a manual air release connected to the top of the tank, unless air can be expelled easily by another means.

(4) A vacuum-type filter system shall be equipped with a vacuum gauge in the piping between the filter and the recirculation pump. The vacuum gauge shall be graduated in inches of mercury, have an appropriate range of readings, and be of a size and location so it can be read easily.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R 325.2155 Cartridge-type filters.

Rule 55. Where a cartridge-type filter system is used, a spare set of cartridges with not less than 100% of the required filtration area shall be provided.

History: 1979 ACS 15, Eff. July 21, 1983.

R 325.2156 Disinfectants and other chemicals.

Rule 56. (1) A chemical or other additive for disinfecting or otherwise treating swimming pool water shall meet all of the following requirements:

(a) Not create objectionable physiological effects.

(b) Not impart toxic or other deleterious properties to the water.

(c) Be compatible in the water with other chemicals and processes normally used in swimming pool water treatment.

(d) Be safely and simply handled and closely controlled in its usage.

(e) Be measured by readily applied poolside tests to determine its concentration, residual, or effectiveness.

(2) A disinfectant may be used only after it has been demonstrated to be as effective in disinfection as a free available chlorine residual of 0.4 milligram per liter at a pH of 7.2 when applied in a concentration which is appropriate, practical, and safe under swimming pool conditions.

(3) The disinfectant shall be applied at a suitable point in the recirculation system for effective disinfection of the recirculating water.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R 325.2157 Chemical feeders.

Rule 57. A swimming pool shall have a chemical feeder and auxiliary equipment for the safe, continuous, controlled application of a chemical for disinfection of the water and the production and maintenance of a suitable residual of the disinfectant. The chemical feeder shall meet all of the following requirements:

(a) Have sufficient capacity for achieving the required disinfectant residual.

(b) Be easily adjustable in output rate.

(c) Be capable of continuous operation.

(d) Be resistant to attack or stoppage by the chemicals intended to be used in it.

(e) Be easily disassembled for cleaning and maintenance.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R 325.2158 Chlorine.

Rule 58. Liquid chlorine (liquefied elemental chlorine gas) shall not be used except with special approval, in writing, from the department. Liquid chlorine may be used only when the department is satisfied of all of the following:

(a) The facilities and equipment are adequate.

(b) The safety precautions are adequate.

(c) The facilities and equipment are operated and maintained by a person qualified by training and experience to do so.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R 325.2159 Chemical test equipment.

Rule 59. Equipment for testing the disinfectant residual, the pH, and any other chemical characteristic of the water determined by the department as important in the control of water quality shall be provided at a swimming pool. A chemical test kit shall be durable, have an appropriate range of standards which are accurate and stable, have fresh reagents, and be simple to use. When a cyanurate is used, test equipment for cyanuric acid level shall be provided.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R 325.2161 Water heaters and thermometers.

Rule 61. (1) A swimming pool water heater piping system shall include an external bypass of the heater if the swimming pool is larger than 3,000 gallons in volume or if the water heater is not designed for at least 100% of the required recirculation flow rate.

(2) A heating coil, pipe, or steam hose shall not be installed in a swimming pool.

(3) A swimming pool with a pool water heater shall have a fixed thermometer at a point in the piping ahead of the pool water heater.

(4) A thermometer shall be graduated to indicate temperature to the nearest 2 degrees Fahrenheit in the operating range. A thermometer shall be installed where it will measure temperature of the flowing water, can be read easily, and will not be subject to damage.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R 325.2163 Vacuum cleaning systems.

Rule 63. A vacuum cleaning system which is capable of cleaning the swimming pool shall be provided for a swimming pool which is larger than 3,000 gallons in volume.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R 325.2165 Safety equipment.

Rule 65. (1) A swimming pool shall be equipped with a long spineboard with ties and with a first aid kit which contains all of the following first aid materials:

(a) Two units of 1-inch adhesive bandage compress.

(b) Two units of 2-inch bandage compress.

(c) One unit of 3-inch bandage compress.

(d) One unit of 4-inch bandage compress.

(e) One unit of 3-inch gauze pads.

(f) One unit of gauze roller bandage.

(g) Two units of plain absorbent gauze, 1/2 square yard.

(h) Two units of plain absorbent gauze, 24 inches by 72 inches.

(i) Three units of triangular bandage.

(j) Scissors.

(k) Tweezers.

(2) A swimming pool, other than a wading pool or a spa pool, shall be equipped with a 12-foot-long rescue pole with blunt ends and a 1/4-inch diameter throwing rope as long as 1 1/2 times the maximum width of the swimming pool or 50 feet, whichever is less, with 1 end attached to an appropriate ring buoy, small float, or rescue tube. A whistle, megaphone, or public address system shall be provided at a swimming pool at which lifeguard service is provided. This equipment shall be readily accessible for emergency use and shall be kept in good repair and a ready condition.

(3) When multiple swimming pools are in the same enclosure, the same safety equipment may be accepted for all of them.

(4) A telephone or other suitable means of communication for emergencies shall be readily available when a swimming pool is open for use. The location of the telephone or other means of communication shall be evident at the swimming pool.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R 325.2171 Mechanical equipment rooms.

Rule 71. (1) Swimming pool mechanical equipment shall be housed in a properly lighted and ventilated structure which affords protection from the weather, is readily accessible and convenient for operation and maintenance, prevents unauthorized access, is properly drained, and enables servicing of the equipment.

(2) A hatch-type opening to a mechanical equipment room shall not be located in a swimming pool enclosure.

(3) A mechanical equipment room at a floor level different from the swimming pool deck shall be easily accessible by a ramp or a stairway.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R 325.2172 Storage areas; offices; other rooms.

Rule 72. (1) Suitable space shall be provided for the storage of chemicals, tools, equipment, supplies, and records where they will be readily available, adequately ventilated, and protected from weather. Physical separation of incompatible chemicals shall be provided.

(2) A storage area, office, mechanical equipment room, or other room adjacent to a swimming pool shall be arranged to minimize traffic by people in shoes across the deck.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R 325.2174 Bathhouse facilities and design.

Rule 74. (1) A swimming pool shall have a bathhouse with dressing, shower, and toilet facilities, except that dressing and shower facilities shall not be required for a wadding pool only.

(2) The bathhouse shall be designed to route the swimmers from the dressing rooms or other rooms to the showers and then directly onto the swimming pool deck.

(3) A toilet room accessible directly from the showers shall be provided. It shall be located where persons will be routed from it to the showers on their way to the swimming pool.

(4) Omission of part or all of the poolside shower and toilet facilities may be approved for a swimming pool when such facilities nearby are available and are readily accessible from the swimming pool. The extent of permissible reductions from the minimum bathhouses fixtures prescribed by R 325.2175 shall depend on the number, availability, and accessibility of the nearby facilities.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R 325.2175 Bathhouse plumbing fixtures.

Rule 75. (1) A bathhouse shall provide showers and toilet facilities in accordance with the specifications of table 2 of this rule.

(2) Table 2 reads at follows (see below):

(3) A shower shall be enclosed, either individually or in a room with others.

(4) A toilet room for males shall have at least 1 water closet, 1 urinal, and 1 lavatory. A toilet room for females shall have at least 1 water closet and 1 lavatory. A toilet facility for a wading pool only shall have at least 1 water closet and 1 lavatory.

(5) A toilet room shall have 1 lavatory for every 2 toilet fixtures, including urinals.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R 325.2176 Bathhouse construction

Rule 76. (1) A bathhouse shall be designed and constructed to promote safe and sanitary conditions.

(2) The floor of a shower room or a toilet room shall be slip-resistant, easily cleanable, and nonabsorbent, with no open joints or cracks. A wall or partition of a shower room or a toilet room shall be easily cleanable and nonabsorbent, with no open joints or cracks. A junction between the floor and a wall or partition shall be covered. The floor shall slope to drains.

(3) A locker shall be of rigid construction and properly vented. It shall be set on legs with the bottom of the locker not less than 6 inches above the floor or on a sold masonry base not less than 4 inches high.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

TABLE 2

Minimum Bathhouse Fixtures

		Number of Toilet Fixtures		
		For Males		For Females
Maximum Bather Capacity* Per R 325.2193	Number of Showers for Each Sex**	Water Closets	Urinals	Water Closets
1-50	1	2	2	2
51-100	2	2	2	3
101-200	3	2	3	4
201-300	4	2	3	5
301-500	5	3	3	6
501-1,000	6	3	4	7

* The number of fixtures for a larger bather capacity shall be extrapolated.

** At a swimming pool used by school classes. 1 shower for every 3 people in the largest class shall be provided for each sex.

R 325.2178 Foot sprays.

Rule 78. (1) A foot spray shall be provided at a swimming pool enclosure entrance for swimming pool users, except at a shower room. A foot spray shall comply with all of the following requirements:

(a) Be supplied from the potable water system.

(b) Have a spray head 18 to 24 inches above the walkway with a conveniently located valve.

(c) Be arranged to spray the bathers from knees to feet as they enter the enclosure.

(d) Have a drain to discharge the water immediately to an outlet without ponding at the drain.

(e) Be located where it will be effective without creating an accident hazard.

(2) A foot bath is prohibited.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R 325.2181 Hose, lighting, heating, and ventilating equipment.

Rule 81. (1) Hose connections and hose adequate for cleaning the swimming pool decks, walkways, and bathhouse shall be provided.

(2) The lighting system for an outdoor swimming pool used at night or for an indoor swimming pool shall illuminate the entire swimming pool area and shall not cause glare. A bathhouse, mechanical equipment room, or storage area shall be illuminated. A lighting fixture shall be protected against breakage.

(3) A bathhouse, mechanical equipment room, storage area, or an indoor swimming pool enclosure shall be adequately heated and ventilated. A heating unit shall be kept from contact with swimmers. A fuel-burning heating unit shall be properly provided with air for combustion and properly vented to the outdoors. Room ventilation shall prevent direct drafts on swimmers and shall minimize condensation damage.

(4) Compliance with this rule does not relieve a swimming pool owner from complying with a state or local code or requirement which is not in conflict with this rule.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

PART 3. OPERATION AND USE

R 325.2191 Pool doors and grates; use of safety equipment; surface maintenance; storage of chemicals; suits and towels; soap; trampolines.

Rule 91. (1) A door or a gate in a swimming pool enclosure shall be kept closed. A door or a gate shall be locked while the swimming pool and the deck are not open for use. A service entrance door or gate shall be locked while the swimming pool is open for use.

(2) Safety equipment shall be used only for its intended purpose and shall not be removed from its established location. A lifeline separating shallow and deeper areas shall be kept in its intended place, except when removed for supervised activity.

(3) All surfaces within a swimming pool enclosure, bathhouse, and related facilities shall be kept clean, sanitary, and in good repair.

(4) A chemical shall be stored in the original container with a label, away from flammables and heat, and in a clean, dry, and well-ventilated place which prevents unauthorized access to it and which prevents accidental spillage and mixing with other chemicals.

(5) Where swimming suits or towels, or both, are furnished to swimming pool users, they shall be thoroughly laundered after each use. The supply of clean suits and towels shall be kept separated in storage and handling from used, unlaundered suits and towels.

(6) Soap shall be provided at each lavatory and at each shower.

(7) A trampoline in a swimming pool enclosure shall not be used, or be accessible for use, without supervision.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R 325.2192 Swimming pool use.

Rule 92. (1) A person who has an infectious or communicable disease shall be excluded from a swimming pool. A person with a bandage or with a possible infectious condition such as a cold, skin eruption, open blister, or inflamed eyes shall be excluded from a swimming pool. A person with such a condition may be granted use of a swimming pool upon presentation of a physician's written statement that the condition is not communicable.

(2) A person who uses a swimming pool shall take a cleansing shower in the nude, using warm water and soap and thoroughly rinsing off all soap suds, before entering the swimming pool enclosure. A person who leaves a swimming pool to use toilet facilities shall take another cleansing shower before returning to the swimming pool.

(3) The apparel worn in a swimming pool shall be clean.

(4) A person shall not spit or otherwise pollute swimming pool water or related facilities.

(5) Running or boisterous or rough play, except for supervised water sports, is not permitted in a swimming pool enclosure or bathhouse.

(6) A person in street clothes or shoes, except a person whose official duties require entry, is not permitted in a swimming pool enclosure when the swimming pool is open for use.

(7) An object or material which might create hazardous conditions or interfere with efficient operation of the swimming pool is not permitted in a swimming pool enclosure. When the owner or operator allows food or drink and associated articles in a swimming pool enclosure, the owner or operator shall provide poolside control to maintain safe and sanitary conditions. Food preparation is not permitted in a swimming pool enclosure. A sign conveying the intents of these requirements shall be displayed prominently at a swimming pool.

(8) The consumption of alcoholic beverages in a spa pool is not permitted. A sign warning against the

consumption of alcoholic beverages in a spa pool shall be prominently displayed at a spa pool.

(9) A pet or other animal, except a trained guide dog accompanying a blind person, is not permitted in a swimming pool enclosure or room.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R 325.2193 Bather capacity limits.

Rule 93. (1) The number of persons in bathing apparel within a swimming pool enclosure shall not exceed the bather capacity limit established by the department or designated local health department.

(2) The bather capacity limit shall not exceed the sum of 7 persons per 100 square feet of water surface area where the water depth does not exceed 5 feet, 4 persons per 100 square feet of water surface area where the water depth exceeds 5 feet, and 1 person per 100 square feet of usable deck area within the swimming pool enclosure. The bather capacity limit is a spa pool shall not exceed 1 person per 3 lineal feet of pool bench inner perimeter, excluding the means of egress. A smaller bather capacity limit may be established for irregular conditions or where satisfactory water quality is not maintained.

(3) The bather capacity limit shall be prominently displayed within the swimming pool enclosure.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R 325.2194 Water quality standards.

Rule 94. (1) A suitable residual of the disinfectant shall be maintained throughout the swimming pool water. The water shall be tested frequently enough before and during each period of swimming pool usage to assure maintenance of suitable residuals. The minimum disinfectant residual maintained, in milligrams per liter, shall satisfy the specifications of table 3 of this rule.

(2) Table reads as follows (see below):

(3) The minimum disinfectant residual maintained with a different disinfectant shall be that which is as effective as a free available chlorine residual of 0.4 milligram per liter at a pH of 7.2.

(4) The pH of the swimming pool water shall be maintained between 7.2 and 8.0. The pH shall be tested at least once each day and more frequently if necessary for control.

(5) The cyanuric acid level of the swimming pool water shall not exceed 100 milligrams per liter. When a cyanurate is used, the cyanuric acid level shall be tested at least once each week and more frequently if necessary for control.

(6) The water temperature of a swimming pool shall not be more than 86 degrees Fahrenheit, except with approval from the department. When water temperature higher than 86 degrees Fahrenheit is approved, it shall not exceed 104 degrees Fahrenheit, and a caution sign, acceptable to the department, stating the actual water temperature shall be prominently displayed at the pool.

(7) A swimming pool shall be used only when the water is sufficiently clear to really discern the main outlet grating from a horizontal distance up to 30 feet.

(8) If a swimming pool becomes polluted with feces, vomit, sewage, or other material, the swimming pool shall be closed from use immediately. It shall be drained, scrubbed, and refilled, or other suitable action shall be taken as approved by the department or designated local health department before further usage.

(9) Visible dirt on the bottom of a swimming pool or floating on the water surface shall be removed promptly.

(10) A spa pool shall be drained, cleaned, and refilled as a frequency necessary to maintain sanitary conditions.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R 325.2195 Bacteriologic analysis.

Rule 95. (1) The owner of a public swimming pool shall be responsible for the collection and the examination of water samples for bacteriologic analysis. The samples shall be collected from the swimming pool at least once each week, or more often if directed by the department or by a designated local health department when unusual conditions dictate, and shall be submitted promptly to a laboratory acceptable to the department. The department or designated local health department may reduce the sampling frequency if there is an acceptable history of operation and water quality. The water samples shall be collected and examined in accordance with generally accepted procedures. The department or designated local health department may reduce the frequency of testing for the standard plate count if the elapsed time between sample collection and analysis exceeds 8 hours.

TABLE 3

Disinfectant Residuals

Disinfectant	Type of Residual	pH 7.2-7.6	pH 7.7-8.0
bromine	bromine	1.0	2.0
chlorine	free available chlorine	0.4	1.0
chlorinated cyanurate	free available chlorine	1.0	1.5

(2) The presence of organisms of the coliform group or a standard plate count of more than 200 bacteria per milliliter, or both, in 2 consecutive samples or in more than 10% of the samples in a series, as shown by valid tests, is unacceptable water quality.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R 325.2196 Water treatment.

Rule 96. (1) Swimming pool water shall be recirculated, filtered, and disinfected continuously, 24 hours per day, at a flow rate sufficient to recirculate the swimming pool volume of water within the required time period, without interruption, except for cleaning the filters or for other maintenance and repairs.

(2) A swimming pool shall not be used when its water treatment equipment is not functioning properly.

(3) The water level in a swimming pool shall be maintained at an elevation suitable for continuous skimming flow into the overflow system without flooding it.

(4) A chemical feeder shall be used for applying only a chemical which the department accepts for application by the chemical feeder.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R 325.2197 Supervisory personnel.

Rule 97. A qualified person responsible for testing the water and for operating the water treatment equipment of a swimming pool shall be readily available when it is open for use.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R 325.2198 Lifeguards.

Rule 98. (1) Lifeguard service shall be provided at a swimming pool, other than a wading pool or a spa pool, if the swimming pool is owned or operated by a government, a governmental subdivision or agency, a public corporation, or a school, or if the total water surface area within the swimming pool enclosure exceeds 2,400 square feet.

(2) Where lifeguard service is required by subrule (1) of this rule, 1 lifeguard for every 75 people within the swimming pool enclosure shall be on duty in the enclosure when the swimming pool is open for use.

(3) A lifeguard shall meet all of the following requirements:

(a) Be a capable swimmer and be competent in lifesaving methods.

(b) Have satisfactorily completed a recognized course of instruction in cardiopulmonary resuscitation and other first aid measures of the type offered by the American red cross or the Michigan heart association. Valid and current evidence of successful completion of the course shall be posted at the swimming pool when it is open for use.

(c) Have satisfactorily completed a recognized advanced or senior lifesaving course of instruction of the type offered by the American red cross or the young men's Christian association. Valid and current evidence of successful completion of the course shall be posted at the swimming pool when it is open for use.

(d) Be dressed suitably to enter the water and act in an emergency.

(e) Not engage in activities which would distract from the proper supervision of persons using the swimming pool or prevent immediate attention to a person in distress.

(f) Have authority and responsibility to enforce rules pertaining to safety and sanitation.

(4) At a swimming pool where lifeguard service is not required by subrule (1) of this rule and is not provided, a sign warning that there is no lifeguard on duty, in legible letters not less than 4 inches high, shall be prominently displayed.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

R 325.2199 Operation reports.

Rule 99. A swimming pool operator shall record daily, on a report form furnished by or acceptable to the department, the swimming pool operational data and information about rescues, submersions, and accidents given medical attention. The department or a designated local health department may require the operator to submit a completed operation report to the department or the designated local health department within 10 days after the end of each month in which the swimming pool is in operation.

History: 1954 ACS 67. Eff. Mar. 24, 1971: 1979 AC: 1979 ACS 15, Eff. July 21, 1983.

PESTICIDE EMERGENCY INFORMATION

For any type of an emergency involving a pesticide, immediately contact the following emergency information centers for assistance.

Current as of September 1997

Human Pesticide Poisoning

MICHIGAN POISON CONTROL SYSTEM

From anywhere in Michigan, call

1-800-POISON 1

1-800-764-7661

Special Pesticide Emergencies

Animal Poisoning

Your veterinarian:

Phone No. ____________________

or

Animal Health Diagnostic Laboratory (Toxicology)
Michigan State University:
(517) 355-0281

Pesticide Fire

Local fire department:

Phone No. ____________________

and

Fire Marshal Division,
Michigan State Police:
M–F: 8–12, 1–5
(517) 322-5847

Traffic Accident

Local police department or sheriff's department:

Phone No. ____________________

and

Operations Division,
Michigan State Police:
****(517) 336-6605***

* ***Telephone Number Operated 24 Hours***

Environmental Pollution

Pollution Emergency Alerting System (PEAS), Michigan Department of Environmental Quality:

District MDEQ Office Phone No. ____________________

and

For environmental emergencies:
****1-800-292-4706***
also
****1-800-405-0101***
Michigan Department of Agriculture Spill Response

Pesticide disposal information

Michigan Department of Environmental Quality.
Waste Management Division.
Monday– Friday: 8 a.m.–5 p.m.
(517) 373-2730

National Pesticide Telecommunications Network

Provides advice on recognizing and managing pesticide poisoning, toxicology, general pesticide information and emergency response assistance. Funded by EPA, based at Oregon State University.
Monday – Friday; excluding holidays
6:30 a.m. – 4:30 p.m. **Pacific Time Zone**
1-800-858-7378
FAX: 1-541-737-0761

Revised by Julie S. Johanningsmeier, *Pesticide Education Program, Michigan State University Extension*

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Pesticide Research Center
East Lansing, MI 48824

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Your input is valuable for making the pesticide certification training manuals appropriate for your industry.

Please take a moment to fill out this evaluation form for this manual, *Swimming Pool Pest Management: A Training Manual for Commercial Pesticide Applicators and Swimming Pool Operators, E2621* and return it to the Pesticide Education Program office, Michigan State University Extension.

1. Were the learning objectives at the beginning of each chapter useful to your study of this manual? Yes or No

2. Did you work through the review questions at the end of each chapter? Yes or No

   If yes, did you find them helpful for preparing to take the Michigan Department of Agriculture (re)certification exam? Yes or No

3. Is there information that you believe would enhance the usefulness of this training manual that was NOT included? Please explain.

4. Were the pest management methods described in this manual typical of those used by people in your industry? Yes or No.

   If no, please explain.

5. Do you feel the MDA certification exam reflects the information found in this manual?

6. Please share with us your comments on how we can improve this or other pesticide certification training manuals or the pesticide certification process.

Thank you for your time and input. This sheet can be folded in thirds, stapled or taped closed and mailed back to the Michigan State University Extension Pesticide Education Program Office, Agriculture Hall, East Lansing, MI, 48824 or returned to your local county Extension office that will forward or FAX it to us (517) 353-4995.

Thanks again!

Your name, address and telephone number (optional):

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Thanks again!

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