CHAPTER 4

POOL WATER TESTING

LEARNING OBJECTIVES

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

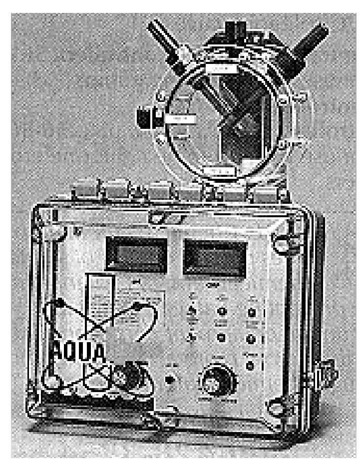
- Compare different pool water testing methods for chlorine.
- Explain the procedures for collecting water samples used in testing.
- Explain the method for colormetrically testing the pH of water.
- Explain what elements constitute water hardness.
- Explain characteristics of low and high water hardness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

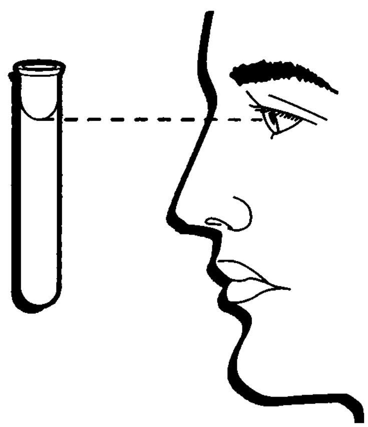
Regardless of the system used, all applicators must follow basic rules when testing water. Disinterest, sloppy instrument handling, hurried procedures, bad reagents, poor choice of sampling location, or inaccurate measurements will lead to problems.



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

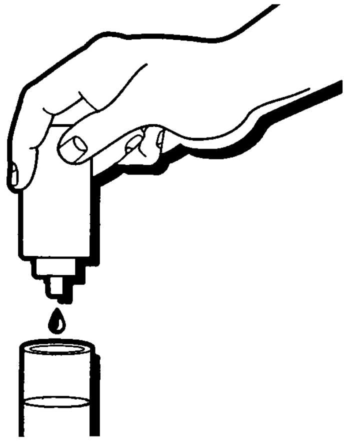
Before initiating any water tests, read the specific kit directions and be familiar with procedures. Before and after each test, the cells of the test kit (viewing tubes) must be cleaned to insure exact test results. The pool operator should rinse the vial with pool water and:

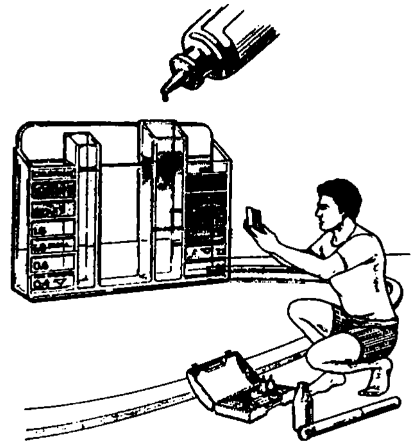
a. Take the sample from the pool 12 inches below the water's surface away from water inlets.
b. Add reagent #1 tablet, or liquid reagent #1 and #2 to the proper viewing tube containing the pool water to measure free available chlorine residual.
c. Add reagent #3 tablet if testing for combined or total 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.

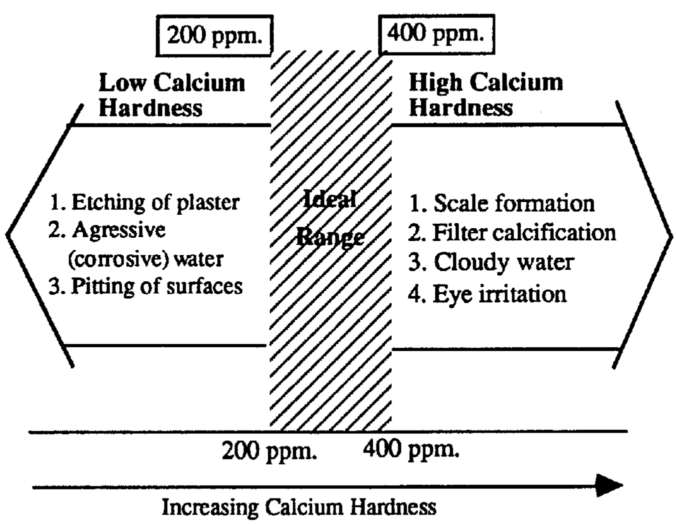
Testing for Calcium Hardness Levels

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)

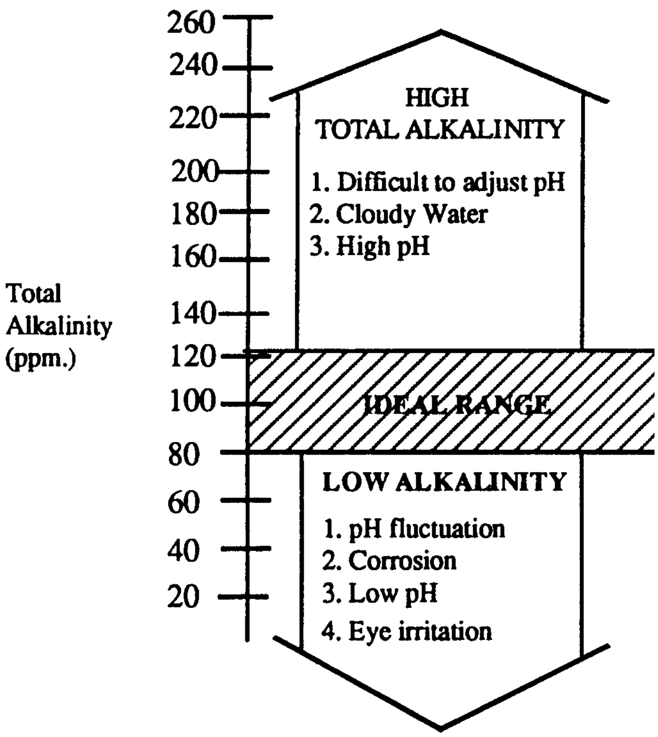
Alkalinity in water represents the amount of bi-carbonates, carbonates, hydroxide and sometimes borates, silicates and phosphates. Total alkalinity is the resistance of water to changes in pH. The higher the total alkalinity, the more difficult it is to change the pH with soda ash or acid.

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?