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Pool Tip #56: Pool Water Testing

As most experienced pool operators know, it's usually easier to avoid a water chemistry related problem than it is to solve it. For instance, it's difficult to eliminate an algae bloom once it has discolored and clouded the water. By time patrons are complaining of skin rashes, dermatological problems, or bacterial infections acquired from contact with contaminated pool water or poorly ventilated natatorium air, it's too late to prevent the spread of the disease. Once the pool walls are stained, or pool equipment has corroded, the damage has already occurred. By frequently monitoring the chemical content of water, accurately testing the ingredients of the water using quality test reagents and instruments and proper water sampling techniques, calculating proper dosages of chemicals needed for adjustment, correctly applying chemicals to the pool, and maintaining recommended levels, many costly and time consuming water chemistry problems can be prevented.

Pool operators should become more familiar with good water testing and analysis practices, and be knowledgeable about common water tests, the recommended frequency of performing testing procedures, various types of test kits and instruments available, proper testing methodology, how to avoid common testing errors, and the importance of keeping accurate records of water test results.

Proper Testing Methods

Test results should be consist and repeatable. Two different people performing the tests at the same time should get the same results. It is important to carefully read and follow the test kit manufacturer's directions.

When analyzing pool water, it is important to obtain a representative sample of water from the pool. It is best to gather water samples from at least 12 to 18 inches below the surface of the water. Do not take water samples in close proximity to perimeter return inlets, nor directly from the return lines in the pump room. If dye tests have indicated the presence of circulation "dead spots", make sure that samples are taken from several areas of the pool, and from both the shallow and deep ends of the pool.

Use a clean, plastic water sample jar. Rinse the jar with pool water several times before collecting the water sample. While holding the jar up-side-down and in a vertical position, plunge the jar below the water surface. When the water level is at your elbow, tilt the jar into an up right position and let the jar fill with water. Cap the jar while its still

submerged. If you are taking samples from more than one pool, make sure to label the sample jars so you don't accidentally mix up the samples.

Many test reagents are temperature sensitive. Directions may indicate that sample water should be allowed to cool to room temperature before tests are performed. After allowing the water to cool, perform the tests within a reasonable amount of time so the water constituents do not change.

Take the water sample jars, test reagents and instruments to a well lit room away from the pool deck. Do not wear sunglasses when interpreting test results. Follow the test kit manufacturer's directions closely in order to obtain accurate results. Make sure all testing equipment and test cells are clean. Adding a reagent to a cell which contains traces of reagents from past tests will affect the accuracy of the test. Empty and rinse all testing instruments after each use. Use fresh reagents, and only apply reagents designed to be used with a specific test kit. Do not interchange or substitute reagents from one manufacturer with those from another test kit manufacturer. Color standards, color intensity and concentration may be different. Hold the test cell at eye level and fill test cells with the sample water to the indicated line, making sure the bottom of the meniscus curve touches the cell fill line.

When using liquid reagents, always hold the reagent bottle in a vertical position. If you hold the bottle like you would hold a pencil, the reagent drop sizes will not be uniform. Make sure you don't accidentally interchange the reagent caps. Put the same cap back on the bottle from which it was removed. Replace the caps on reagent bottles immediately after performing the test. Reagents will react and begin decomposing when exposed to air and their shelf life will be diminished. If you lose count of the number of drops of reagent you've added to a sample, discard the sample and start over.

If you are performing tests which require the use of tablet reagents, do not touch the tablets when you remove them from their foil packets. If the foil packets are torn, or the tablets have gotten wet, discard the reagents.

If using dip and read test strips, bottle caps should be replaced immediately after use. The strips will become reactive with moisture in the air. Check the timing of the tests--the colors change if you wait longer than the time specified. Remember to follow the manufacturer's directions. Many of the tests involve a two step process. For example, total alkalinity, pH, total hardness, and cyanuric acid results are read after 30 seconds, then the test strip is re dipped, swished for an additional 30 seconds and then chlorine and bromine results are read immediately.

Make sure all testing instruments are properly calibrated. Avoid dropping instruments on the pool deck, do not expose test instruments to high levels of humidity, and do not fully submerge testing instruments unless they are sealed and the o-ring or seal is intact.

Make sure the test kit you are using is capable of giving a reading in the range you are likely to encounter in the pool. Purchase wide range test kits. Dilution testing

can be complicated and the operator is more likely to make an error. Watch for bleaching, unusual color appearance, difficulty reaching an end point because sanitizer levels are elevated, tests results which are not within range of the reagent being used, or metal ions that are masking out the titrant and interfering with the tests.

Directions may indicate that a sample should be swirled rather than shaken. If you shake a sample meant to be swirled, oxygen or carbon dioxide in the air will dissolve in the water producing bubbles which may alter test results. If test cell caps are lost or destroyed do not use your fingers to cap test cells, you'll contaminate the sample. Have a supply of extra test cell caps available. Never add test reagents directly to the swimming pool in order to do a quick "flash test". It's not very professional and the results are worthless.

Most reagents have a relatively short life span of less than one year. However, some reagents can go bad in an afternoon if improperly stored. Reagents are stamped with an expiration date, and should be discarded and replaced if they have expired. Store reagents in a cool, dark location. High temperatures may cause reagents to go bad. Do not store reagents on the pool deck in direct sunlight, in the trunk of your car, or in the pump room on top of the heater. Heat and ultraviolet light degrade many common reagents. Do not allow reagents to freeze either, because reagents may crystallize and become useless for further testing. Don't store reagents in a chemical storage area. Pool chemicals, other reagents, and air can be absorbed and contaminate the reagents.

Common Water Tests

Tests should be performed to make sure acceptable chemical levels are being maintained. The operator should look for problems that might contribute to poor water clarity, produce favorable conditions for bacterial and algae growth, cause the water to irritate bathers, or lead to staining and destruction of pool components. Tests kits and instruments should be purchased so the following items can be monitored:

- Free, total and combined chlorine
- Total bromine, or other sanitizers and oxidizers if used
- Cyanuric acid
- Bacteriological water quality
- Oxidation reduction potential
- ph
- Acid and base demand
- Total alkalinity
- Calcium hardness
- Total dissolved solids
- Metals: iron, copper, manganese
- Nitrite and nitrates
- Phosphates
- Clarity

- Water and air temperature
- Relative humidity
- Dissipated chemicals over the pool
- Saturation index

Test Frequency

It is necessary to diagnose water problems before they can be solved. Constant monitoring, evaluating and adjusting of the water ingredients will lead to consistent water quality. Large fluctuations in water chemistry may necessitate costly and time consuming rectification. Several factors govern how often water tests should be performed, including the parameter's tendency to change rapidly, bather load, pool volume, water temperature, turnover time, amount of sunlight shining on the pool, the surrounding environment, code requirements, and whether the pool is residential or commercial. The content of the source water and the dilution rate based on the amount of fresh water being added to the pool can also influence the need for frequent testing.

Pool water should always be tested and corrections made before allowing patrons to enter the water on a given day. Heavily used commercial pools should be tested at least once every one or two hours. Small apartment pools which are primarily decorative and only used by a half dozen residents on an average day may only need to be tested twice or three times per day. Sanitizer levels and pH should be checked at every test. Some chemical levels, like calcium hardness or TDS, are slow to change and need only be performed daily or weekly. Water chemistry changes can occur so rapidly in warm water, heavily used commercial spas that testing, monitoring of pH and ORP, and chemical adjustments must be augmented by the use of automated controllers.

Test Kits and Testing Instruments

Test kits, chemical reagents and testing instruments must be available so that detailed water analysis can be conducted by the pool operator and all chemical levels can be maintained within acceptable ranges. Regardless of the cost or sophistication of the testing equipment, the tests must provide reliable, accurate, repeatable results. Directions should be easy to follow. All staff members required to perform water tests should be thoroughly trained in the use of the testing equipment. Some of the more common types of test kits and instruments found at commercial pools include:

Color Comparitor

Liquid or tablet reagents are added to a water sample and react with a chemical present in the water to produce a color of a specific intensity or shade. Reagents are chemicals used to measure, detect, or analyze another chemical. The color of the test sample is compared to a printed color chart, or liquid encapsulated color standard.

Accuracy of test results is somewhat subjective and depends heavily on lighting conditions and the pool operator's visual ability to differentiate color graduations. (Commonly used to test for chlorine, bromine, and pH).

Colorimeter

Just as is done when using a color comparitor test kit, liquid or tablet reagents are added to a water sample and react with a chemical present in the water. Then the sample is placed in a colorimeter chamber or filter photometer and capped to shield outside light. The pool operator presses a button on the battery operated meter and a light beam is passed through the test tube containing the sample. The amount of light which passes through the sample is detected by a photocell, which then responds by sending an electrical current in proportion to the amount of light detected to an analog or digital display on the meter.

Some colorimeters require that the results be converted using calibration graphs requiring some analytic skills, but most meters being sold to the pool industry today are calibrated to perform specific tests and use an appropriate light color or wavelength so that results can be direct-read. Results from a colorimeter are more accurate and reproducible than those obtained using color comparitors because they do not depend on human visual acuity or ambient light levels. Metering instruments are much more sensitive to tiny variations in color.

Titration

A color change occurs as a measured indicator reagent is added to a test sample. A titrant is added, depending on the manufacturers directions, either drop by drop or by depressing a plunger on a syringe to dispense the titrant until a second distinct color change occurs when an end-point is reached. The amount of titrating reagent added to cause the color change is related to the concentration of the chemical in the sample. Titration is commonly used to test chlorine, bromine, total alkalinity, and calcium hardness levels in pools.

For pool operators who are color blind, or who have trouble color matching or differentiating colors when chlorine levels are greater than 3.0 ppm, titration rather than color comparitor test kits should be used to obtain accurate results.

Two scoops of buffered DPD indicator powder are added to a 25 milliliter pool water sample, turning the sample pink. FAS (ferris ammonium sulfate) titrant is added drop by drop, swirling after each drop, until the sample goes colorless. The endpoint is reached when the pink sample turns to clear. The number of FAS drops added is multiplied by an equivalency factor of 0.2 to obtain a free available chlorine reading to an accuracy of 0.2 ppm. It is possible to tell for instance that a spa contains exactly 9.4 ppm of FAC.

Then to the same sample, DPD reagent #3 is added. If the sample does not

change color, no combined chlorines (chloramines) are present. If the sample turns pink again when DPD #3 is added, the FAS titrant is added again drop by drop until the sample turns clear. The total number of FAS drops added in both the free and total tests multiplied by 0.2 is the total available chlorine reading.

The same kit can be used to test for bromine by multiplying the answers by 2.25, the molecular weight difference between chlorine and bromine, or a special FAS kit for testing bromine can be ordered.

Turbidometric

A test reagent, typically melamine for cyanuric acid level testing, is added to the water sample and forms a suspended non soluble compound or precipitate which clouds the water sample. The higher the chemical concentration, the greater the cloudiness of the solution. The sample is pored slowly into a calibrated test cell until an indicator dot at the bottom of the cell is no longer visible. Some kits raise or lower a test stick down into a test cell instead. When the indicator dot is obscured, the water level in the cell is compared to the calibration scale on the side of the cell. Test results can be read visually or by a photometer.

Neflometric

Neflometers are used to measure water clarity. The meters are usually battery operated, and can test in the range of 0 to 1,000 NTUs without the need to perform calculations or interpolate calibration charts, with a resolution of 0.1 NTUs. The detector compensates for sample color, stray light and light fluctuation. A water sample is taken from the pool, the meter is switched on, the sample solution is placed in the meter, a narrow beam of light is passed through the sample and scattered by the particles. A light detector and a scatter detector collect the light. The digital display can be read directly within approximately 10 seconds.

Laser particle counters are also available, but are out of the price range of most recreational water organizations. However, water samples can be sent to laboratories for laser particle analysis to determine filter efficiency and capability of particle size removal.

Electrometric

Portable electrometric meters are used to measure pH, total dissolved solids, and oxidation reduction potential. An electrode or electrical probe is inserted in a test sample, the battery operated meter is turned on, electrical current passes between the electrodes, then the results are displayed on an electronic meter.

Some of the meters have automatic temperature compensation, and automatically turn off after a set period of interruption to extend battery life. Devices

range from simple, low cost hand held pocket meters to professional laboratory instruments. It should be remembered though, that the inexpensive devices will not have the accuracy of quality laboratory instruments.

The meters must be calibrated frequently, as often as daily. Some meters use a calibration solution of a known standard in order to avoid drift. Others have screwdriver or push button calibration adjustment. The operator must be careful not to drop the meter on the pool deck, or fully submerge the instrument, unless the meter is designed to be immersed (and most are not).

Dip-and-Read Strips

Plastic strips with chemically treated reagent pads, are dipped in the water, and removed. After a 30 second wait for a chemical reaction to take place and color to develop, the reagent pad color is matched to the color patches on the strip container. Single or multiple test strips are available to test for chlorine, bromine, cyanuric acid, nitrite, nitrates, pH, total alkalinity, calcium hardness, and polymeric biguanides. Test strips have a shelf life of between 10 and 20 months depending on the specific test.

Test strip technology was originally developed for the medical industry, and has been adapted for use in the swimming pool industry. The test strips are quick and easy to use, and are a good, quick way to identify problems and determine when further testing needs to be done.

Thermometer

A water thermometer with a direct reading dial on a stainless steel stem probe, with a battery operated analog or digital display is recommended for measuring pool water temperature. The probe is inserted into the pool for a few seconds in order to obtain a result. Inexpensive plastic or glass thermometers which are often tied to a pool ladder or rail and left in the pool are easily broken or stolen. And as every pool operator knows, if a thermometer is left in the pool, patrons will come complain about the water temperature. Half of them will insist the water is too cold, while the other half will complain that the water is too warm.

Volumetric Pump

Volumetric pumps are used with various gas detector tubes to measure airborne contaminant gasses or vapors in the air over the pool, and insure that contaminants are within safe levels specified by OSHA for work environments. Pool operators typically test for chlorine, ozone and carbon dioxide six inches above the pool water surface.

Detector tubes are purchased separately for each of the specific gasses needed to be tested, within a measurable concentration range, usually in boxes of 10 or 12 tubes.

To perform a test, a gas detector tube is selected, the ends of the glass tube are carefully snapped off, the detector tube is inserted into the pump, the pump is stroked and a precisely measured, representative ambient air sample is drawn through the tube and into the pump. Some tests require multiple air samples of an indicated length or volume. Many of the pumps have stroke counters and end-of-stroke or flow finish indicators to help insure more accurate measurements. The chemical vapor drawn into the tube reacts with a reagent and stains the material in the tube. A chemical reading is obtained by observing the stain and referring to the calibrated scale printed on the indicator tube.

If test results show overexposure to a regulated chemical in excess of the permissible exposure limit (PEL) and the level of contaminants cannot be reduced, adjustments must be made in work hours, the environment, or work policies and procedures.

Dosimeters

In order to comply with the OSHA "Confined Spaces" Regulation [29 CFR 1910.146] the employer must provide testing and monitoring equipment at no cost to employees, maintain testing and monitoring equipment properly, and ensure proper use of testing equipment by employees. Before an employee enters a confined space, internal atmosphere of the confined space must be tested with a direct reading, calibrated instrument (dosimeter), for: oxygen level, flammable gasses and vapors, and toxic air contaminants such as hydrogen sulfide, and carbon monoxide.

Most dosimeters have a sensing cell or probe mounted on the end of a cable or wand which is attached to a sampling hose, pump and monitor. Dosimeters are battery operated, have digital read-out displays, and visual and audible alarms that sound to warn the employee of dangerous conditions within the confined space.

The regulation exists to protect workers who must enter confined spaces in order to perform their jobs. In an aquatic setting, large pool filter tanks and surge chambers would be considered confined spaces. The regulation also requires that employers must provide a lifeline and retrieval system, provide harnesses for employees which must be worn when entering a confined space, post a floor sign when employees have entered a confined space, provide annual inspections to insure proper operation of the rescue and recovery winch, purchase a ventilation blower to provide steady, fresh airflow to confined spaces and reduce contaminant levels. The employer must also establish a permit system and controlled entry authorization procedures, and train personnel for confined spaces operations.

Record Keeping

Pool chemical logs are one of the most important records which must be kept in an aquatic facility. The records can provide data for determining costs of operation,

chemical purchases, patron satisfaction, causes and prevention of disease, and for budget recommendations and justification for future expenditures. The daily pool chemical log should be posted. State, federal and local ordinances may require that certain water tests be performed and records maintained to ensure the safety and health of the public. Well maintained documents may be used as part of a successful legal defense in cases of accidents resulting in litigation.

Records should be completed accurately and on time, summarized for the facility owner or aquatic supervisor, and stored for an extended period of time in case documentation or retrieval of information is necessary. Do not forge test results. If it can be shown that pool logs were filled out without the actual water tests being made, the documents will be worthless to your defense. Most state codes require that pool chemical and maintenance logs be kept for a period of not less than 1 to 3 years. However, records should be kept indefinitely if there is any chance they might be needed for review in a legal matter.

Additional Information

For more information on pool water testing, the following resources are recommended:

"Standard Methods for the Examination of Water and Wastewater". Edited by Clesceri, L. S., Greenberg, A. E., and Trussell, R. R., and published by a joint committee of The American Public Health Association, American Water Works Association, and Water Pollution Control Federation. This 1,500 + page book was originally published in 1905, and is in its 20th edition. The comprehensive text covers everything you ever wanted to know about water testing, testing methods and analysis. The book can be found in most research libraries or can be purchased for around $155.00.

"Pool/Spa Water Chemistry and Testing Video". This video is available in VHS format, and examines water chemistry and testing in detail. The video and the accompanying workbook can be ordered from Taylor Technologies.