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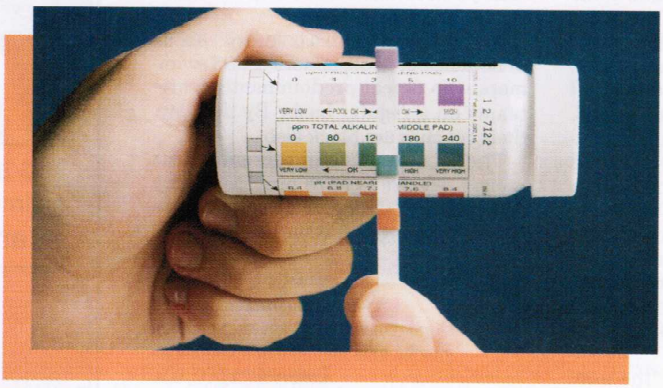
BY DR. ALISON OSINSKI

Testing Gives Pool Water A Passing Grade

As most experienced swimming pool operators know, it's easier to avoid a water chemistry problem than to solve it. For instance, it's difficult to eliminate an algae bloom once it has discolored and clouded the water. By the 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 already has occurred.



Dip-and-read strips, such as these from Environmental Test Systems, are just one method of testing pool/spa water.

To prevent costly and time-consuming water chemistry problems, operators should: frequently monitor the chemical content of water; accurately test the ingredients of the water using quality test reagents and instruments and proper water sampling techniques; calculate proper dosages of chemicals needed for adjustment; correctly apply chemicals to the pool; and maintain recommended sanitizer and pH levels.

Proper Testing Methods

Test results should be consistent 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 and to gather water samples from at least 12 inches to 18 inches below the surface of the water, away from perimeter return inlets. Water samples should not be taken from the recirculation system. If past dye tests have shown the pool has circulation "dead spots," samples should be taken from several areas in both the shallow and deep ends. If any mistakes are made during the water testing process, discard the sample and start over.

To collect the sample, use a clean, plastic water sample jar that has been rinsed several times with pool water. While holding the jar upside-down and vertical, plunge the jar below the water surface to elbow depth, tilt the jar so it fills with water and cap the jar while it is still submerged. If taking samples from more than one pool, be sure to label the sample jars. Many test reagents are temperature-sensitive. Although testing directions may instruct that sample water be allowed to cool to room temperature before tests are performed, do not wait so long that the water constituents change.

After collecting the sample, take the water sample jars, test reagents and instruments to a well-lit room for reading. Follow the test kit manufacturer's directions closely in order to obtain accurate results, making sure that all testing equipment and test cells are clean. Adding a reagent to a cell with traces of reagents from past tests may yield inaccurate results. To prevent this problem, 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.

Hold the test cell at eye level and add the required amount of sample water, 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, so the reagent drop sizes will be uniform. Replace the caps on reagent bottles immediately after performing the test, making sure to put the same cap back on the bottle from which it was removed. If over-exposed to the air, reagents will react and begin decomposing, thus shortening their shelf life. If test cell caps are lost or destroyed, do not use your fingers instead of a cap because the sample could become contaminated. Instead, 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 is not very professional and the results are worthless.

If performing tests that use tablet reagents, do not touch the tablets when removing 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 to prevent the strips from reacting with moisture in the air. Check the timing of the tests — the colors change if too much time lapses. Many of the tests involve a two-step process. Total alkalinity, pH, cyanuric acid and total hardness 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 the test kit is designed to give readings in a wide enough range to reflect the parameters likely to be encountered in the pool. Dilution testing can be complicated, and the operator is more likely to make an error. Do not wear sunglasses when interpreting test results. Directions may indicate that a sample should be swirled rather than shaken. If a sample meant to be swirled is shaken, oxygen or carbon dioxide in the air will dissolve in the water and produce bubbles that may alter test results.

Most reagents have a relatively short life span, usually less than a year. However, some reagents can expire in one afternoon if they are improperly stored. Reagents should be stored in a cool, dark location. Expired reagents should be discarded and replaced. Because heat and ultraviolet light degrade many common

reagents, do not store reagents on the pool deck in direct sunlight, in the trunk of a car or in the pump room on top of the heater. Neither should reagents be subjected to freezing temperatures, as they may crystallize and become useless for further testing. Also do not store reagents in a chemical storage area, because pool chemicals, other reagents and air can be absorbed and contaminate the reagents.

Wayne Ivusich, technical coordinator for Taylor Technologies, Sparks, Md., answers the company's technical support line and fields a variety of water testing questions from aquatic professionals. The most common problems he said he encounters include bleaching, unusual color appearance or difficulty reaching an end point because sanitizer levels are elevated, tests results are not within range of the reagent being used or metal ions are masking out the titrant and interfering with the tests.

Common Water Tests

Tests should be performed to make sure acceptable chemical levels are present. 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. The operator should be capable of determining:

- Free, total and combined chlorine;
- Total bromine or other sanitizers and oxidizers;
- Cyanuric acid;
- Bacteriological water quality;
- Oxidation reduction potential;
- pH;
- Acid and base demand;
- Total alkalinity;
- Calcium hardness;
- Total dissolved solids (TDS);
- Iron, copper and manganese;
- Nitrite and nitrates;
- Water clarity;
- Water and air temperature;
- Relative humidity;
- Dissipated chemicals over the pool; and
- Saturation index.

Pool water always should 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. Pools that are primarily decorative or have a light bather load may only need to be tested two or three times per day. Sanitizer levels and pH should be checked at every test. Some factors, such as calcium hardness or TDS, are slow to change and need only be performed daily or weekly. According to Judith Sperling, aquatics director at the University

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Putting Pool/Spa Water to the Test

Commercial swimming pool and spa operators have a responsibility to ensure that the water in which their patrons swim or soak meets or exceeds minimum health standards. A variety of test kits and testing equipment is available to determine that these standards are being met.

While most pool managers still rely on a traditional color comparator test kit to check water quality, technological innovations such as dip-and-read strips and electronic meters and monitoring devices are making water testing tasks easier and more reliable.

Regardless of the cost or sophistication of the testing equipment, the tests must be performed so they provide accurate and repeatable results. Staff members required to perform water tests should be thoroughly trained.

Testing equipment, such as the commercial test kit from Taylor, above left, and the colorimeter from LaMotte Co., above right, is important in maintaining pool water quality.

The following glossary provides definitions of many of the terms that relate to test kits and descriptions of the testing equipment commonly in use at commercial pools today:

Color Comparator — In this type of kit, 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. The accuracy of these test results depends heavily on lighting conditions and the pool operator's visual ability to differentiate color gradations. Color comparator kits can be used to determine all necessary chemical parameters.

Colorimeter — Just as is done when using a color-comparator kit, liquid or tablet reagents are added to a water sample and react with a chemical present in the water. The sample is then 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 passing through the sample is detected by a photocell, which responds by indicating 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, although 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 read directly. Colorimeter results do not depend on human visual acuity or ambient light levels and, therefore, tend to be more accurate and reproducible. Units are available that test for single or multiple parameters.

Dip-and-read strips — These plastic strips with chemically treated reagent pads are dipped into the water and removed. After a brief 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 factors including chlorine, bromine, cyanuric acid, nitrite, nitrates, pH, total alkalinity, calcium hardness and polymeric biguanides. To test for sanitizer level, the strips use syringaldazine and vanillinazine, which display results in shades of blue. Test strips generally have a shelf life of between 10 and 20 months, depending on the specific test. Test strip technology originally was developed for the medical industry and has been adapted for use in the swimming pool industry. Test strips "are a good, quick field screen to identify problems and determine when further testing needs to be done," and are currently being used by pool operators, health inspectors and even church officials, who use the strips to test the water in baptismal fonts, according to John Simon, director of marketing and sales for Environmental Test Systems.

DPD — Diethyl-p-phenylenediamine (DPD) is a commonly used testing reagent for determining the bromine or chlorine level of a pool water sample. DPD is available in several forms, including liquid and tablets. DPD testing turns the water varying shades of pink and also allows the operator to distinguish between free and combined chlorine levels.

Electrometric meters are portable and 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 and the results are displayed on an electronic meter. Some of the meters feature automatic temperature compensation and automatically turn off after a set period of interruption to extend battery life. The devices range from simple, inexpensive, handheld pocket meters to professional laboratory instruments. Such meters require calibration and must not be dropped onto the pool deck or fully submerged in water, unless the meter was designed to be immersed.

Neflometers are used to measure water clarity. The meters generally are battery-operated and compensate 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 within approximately 10 seconds. Laser particle counters are also available, but at upwards of $30,000, they 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.

OTO — Orthotolidine (OTO) is a reagent that turns the sample yellow and is used for testing the level of total available chlorine. Because color intensity continues to change with OTO, readings usually are not reliable after a few seconds. False results may also be obtained because of the interference of dissolved metals, particularly iron or manganese, with the reagent. In addition, OTO has been banned for pool water testing in some states. It is a known carcinogen and should not be handled without taking appropriate precautions.

Reagents — Many pool water tests, especially those using color comparators, involve the addition of another chemical to the water sample. Adding chemicals, such as DPD (diethyl-p-phenylenediamine) and OTO (orthotolidine) for sanitizers or phenol red for pH, to the sample results in another color change that is read to determine the sanitizer or pH level of the sample.

Thermometer — Used to measure pool water temperature, a thermometer with a direct-reading dial on a stainless steel stem probe, with a battery-operated analog or digital display, is recommended. The probe is inserted into the pool for a few seconds in order to obtain a result. Inexpensive plastic or glass thermometers, which often are tied to a pool ladder or rail and left in the pool, are easily broken or stolen.

Titration testing is a method of applying measured amounts of testing reagents to a water sample to effect a color change. For example, a specific amount of a DPD reagent is added to a predetermined size of water sample to turn the sample pink. A titrant is then added, depending on the manufacturer's directions, either drop by drop or by depressing a plunger on a syringe to dispense the titrant until a second distinct color change occurs — from pink back to clear, for example — and an end point is reached. The operator keeps track of the amount of titrating reagent added to cause the second color change, which directly relates to the concentration of the chemical being tested for in the sample. The titration method is commonly used to for test chlorine, bromine, total alkalinity and calcium hardness levels in pool water. Because readings from this method are determined by the amount of reagent added to a sample, such testing offers an advantage 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.

Turbidometric testing involves the addition of a test reagent — typically melamine for cyanuric acid level testing — to the water sample to form a suspended, non-soluble compound or precipitate that clouds the water sample. The higher the chemical concentration, the greater the cloudiness of the solution. The sample is poured 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.

Volumetric pumps are used with various gas-detector tubes to measure airborne contaminant gases or vapors in the air over the pool and ensure that contaminants are within safe levels as specified by EPA or OSHA for work environments. Pool operators typically test for chlorine, ozone and carbon dioxide at a level 6 inches above the pool water surface. Detector tubes are purchased separately for each of the specific gases to be tested. 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. 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.

Regardless of the testing method your facility selects, regular testing and monitoring of the pool/spa water quality will go a long way in keeping patrons happy and healthy.

— Dr. Alison Osinski

For more information on the equipment discussed above, refer to the list of suppliers in the Water Testing Equipment section of the 1994 Buyers' Guide, included in the November/December 1993 issue of AQUATICS INTERNATIONAL.

Pool/Spa Test Level Recommendations

MEASUREMENT	RECOMMENDED LEVEL
Oxidation Reduction Potential (ORP)	750 mV (Commercial)
Free Available Chlorine (FAC)	3.0 - 5.0 ppm (Up to 10.0 ppm) or as needed to maintain 750mV ORP
Total Available Chlorine (TAC)	No more than 0.2 ppm higher than the FAC
Combined Available Chlorine (CAC)	<0.3 ppm
Total Bromine	4.0 - 6.0 ppm, or as needed to maintain 750mV ORP
Cyanuric Acid	20 - 30 ppm maximum (Outdoors) 0 ppm (Indoors)
Polymeric Biguanide	30 - 50 ppm
pH	7.2 - 7.8
Acid or Base Demand	Neither
Total Alkalinity	80 - 120 ppm
Calcium Hardness	200 - 300 ppm
Total Dissolved Solids (TDS)	<1,500 ppm
Saturation Index	0 (± 0.3 acceptable)
Iron	0 - 0.2 ppm
Copper	0 - 0.3 ppm
Manganese	0 - 1.5 ppm
Nitrates	<10 mg/l (Uncontrollable algae problem likely at 25 mg/l)
Clarity	Crystal clear (<0.5 NTU)
Water Temperature	104° F (Maximum spas) 86°-94° (Therapy pools) 78°-82° (Competitive pools) 83°-86° (Multi-use pools)
Air Temperature	2°-7° F above pool water temperature
Chlorine Gas Present In Air Over Pool	0, but 1.0 ppm permitted for up to 8 hours
Ozone Gas Present In Air Over Pool	0, but 0.1 ppm permitted in air 6 inches above water surface for an 8-hour work shift in a 40-hour week
Bacteriological Water Quality	<200 bacteria per millimeter as determined by standard plate count, and total coliform organism most probable number count of less than 2.2 per 100 milliliters of sample

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of California at Los Angeles, who is responsible for four outdoor pools and a diving well, water quality tests are performed by both employees of the university's facilities division and the lifeguards on duty.

"The facilities division tests daily, while the lifeguards test every two hours with a DPD test kit. The only tests the lifeguards do are chlorine and pH, which they learn to do during their in-service training," Sperling said. Test kit instructions also are included in the facility's policy manual.

"These tests are done strictly as a backup to the Stranco and Chemtrol chemical controllers that are installed on the pools. Within the next couple of weeks, the system will be computer-connected so the chlorine and pH can be checked from a modem," she said.

Bacteriological quality analysis tests should be performed on a regular basis, weekly or monthly or as required by code. If a pool operator tests only for chemical levels in the water and does not monitor bacterial growth, a bacterial contamination problem will go unnoticed until bathers complain of infection.

Bacteriological quality of the water should be consistently acceptable as defined by having less than 200 total bacteria per millimeter as determined by standard plate count, and total coliform organism most probable number count of less than 2.2 to 4 per 100 milliliters of sample. Total coliforms can be any of several bacilli found in the human large intestine. Their presence in test samples indicates fecal contamination of the pool. Tests for salmonella, shigella, giardia and E. coli should be performed occasionally.

"Bacteria testing, because of the public's concern about disease transmission, will become more common, I believe. At our facilities, this is something that we will be doing more of in the future," Sperling said.

Tests for the presence of Pseudomonas aeruginosa also should be performed frequently. Water samples should be collected from the water, and swabs should be used to collect samples from inside the filters and hair-and-lint strainers. Although it is not uncommon to find Pseudomonas bacteria present in pool or spa water, uncontrolled growth of P. aeruginosa and the resulting outbreaks should not occur in properly treated and rigorously maintained pools. Unfortunately, widespread outbreaks are becoming common in the aquatic industry. Warm, moist, aerated environments present favorable conditions for bacterial growth. Pseudomonas can grow in swimming pool water as well as spa water, on the pool edge and decks, in filter liners, in

the filter media, in garden hoses left coiled on a pool deck and inside PVC circulation pipe.

Most pool operators contract with independent laboratories to test for Pseudomonas, although a test was recently introduced by Health and Leisure Concepts, Fort Lauderdale, Fla., that allows pool operators to test on-site for general bacteria, coliform bacteria, Pseudomonas, fungal yeasts and molds.

If testing reveals high levels of Pseudomonas in the pool or on pool surfaces, immediate steps must be taken to eliminate the problem before a general outbreak occurs. Solving a Pseudomonas problem is time- and work-intensive. Before starting the process, make sure all staff members read the Material Safety Data Sheets (MSDS) and have available the appropriate protective clothing and equipment, including goggles, work clothing that covers all areas of exposed skin, a half mask respirator with fresh chlorine cartridges and particle filters, rubber boots and Neoprene gloves.

Bob Carvotta, aquatic director at the Jewish Community Center of Rochester, N.Y., related how he recently eliminated a pervasive Pseudomonas problem. Members were complaining about rashes, "a few at first then every week a couple of more." Once the problem was identified and a solution found, Carvotta and his staff began the steps necessary to eradicate the problem.

First, they drained the pool, did some minor repairs, chlorine washed the pool walls, removed 5,000 pounds of sand and gravel from the 36-inch-diameter high-rate sand filter tanks and scrubbed the insides of the filters with a brush. They closed the main drain and gutter valves, poured a solution of 20:1 water and sodium hypochlorite into the gutter and main drains until the pipes were filled to the top and then flooded the gutters with the solution and let everything sit for four days. They replaced the laterals and No. 20 silica in each filter tank, filled the tanks with the 20:1 water and chlorine solution and let them sit for another two days.

Now, Carvotta sends a water and sand sample to a lab every two months for analysis. Every other month, he isolates each filter, cleans the sand media with a commercially available filter cleansing product and fills the tank with a 20:1 water:chlorine solution before going back to normal operation. He also purchased portable ORP and TDS meters and has started to maintain higher FAC levels required to prevent the growth of Pseudomonas in the pool.

"My staff and I spent more than 150 hours solving this problem that could have been prevented. The work was backbreaking — my back still hurts from scrubbing the pool and shoveling all that sand out of the filters."

Test Frequency

Water problems must be diagnosed before they can be solved. Constant monitoring, evaluation and adjustment of the water ingredients will lead to consistent water quality. Several factors govern how often water tests should be performed, including:

- The parameters' tendency to change rapidly;
- Bather load;
- Pool volume;
- Water temperature;
- Turnover time;
- Amount of sunlight reaching the pool;
- Surrounding environment;
- Code requirements;
- Content of the source water; and
- The dilution rate, which is based on the amount of fresh water being added to the pool.

At Marian College, Indianapolis, John Drew, maintenance and grounds supervisor, uses a manual test kit to back up the results shown by the readouts on the

pools' automatic chemical controllers. He tests the water several times a day on the indoor and outdoor pools, particularly when the bather load is heavy or the sun is causing a lot of water and chemical evaporation.

"We manually apply chemicals to the indoor pool, which is used for instruction and kept at about 86°F. We test the water temperature manually in the inside pool because it needs to be appropriate for competition or instruction," Drew said.

Drew also has trained several members of the mechanical maintenance staff to perform the tests in his absence.

Record Keeping

Just testing the water is not enough. Pool chemical logs are among an aquatic facility's most important records and can provide the necessary data to determine costs of operation, chemical purchases, patron satisfaction, causes and prevention of disease, 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 comprehensive risk management plan that contributes to a successful legal defense against litigation.

Dave Waldrop, control specialist, maintenance department, Tarrant County Junior College, N.W. Campus, Fort Worth, Texas, maintains the college's indoor, 50-meter pool, which is temperature- and humidity-controlled via a building control system and automatic chemical controllers.

"The operations department does the testing, primarily to back up the chemical controller, which actually can be monitored in conjunction with the building control systems. I can trend the data and control the alarm parameters and get a printout as needed," he said. "If I get a pH alarm or a chlorine alarm, I specifically get a printout on those."

Waldrop said all new pool operators at the facility are trained in the appropriate use of the test kits and method of documenting the results. "We use a booklet that we have prepared to train them. When they do the test, they fill out a form that indicates the results of their color comparator readings. One of the problems we encounter sometimes is that discrepancies arise among operators, so what I have done is use a pH probe with a digital readout and some other testing for chlorine, to get a more accurate reading. I try to select an operator who can pretty well get the color comparison correct. A photometer is used sometimes to provide a third comparison," he said.

Records should be completed accurately and on time, summarized for the facility owner or aquatic supervisor and stored in case documentation or retrieval of information is necessary. Most state codes require that pool chemical and maintenance logs be kept at least one to three years. However, records should be kept indefinitely if there is any chance they might be needed for review in a legal case.

Properly treated pool water, followed up with accurate testing procedures will reduce the likelihood of pool damage and the spread of disease. By utilizing the right testing system, following the directives of the test kit manufacturer and the appropriate bathing codes and documenting the findings of the tests, a facility manager can prevent problems before they negatively impact the facility.

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