NSF/ANSI 50-2007

Circulation system components
and related materials for
swimming pools, spas / hot tubs

2 Definitions

2.1 accessible: Fabricated to be exposed for cleaning and inspection using simple tools (e.g., screwdriver, pliers, open-end wrench).

2.1.1 readily accessible: Fabricated to be exposed for cleaning and inspection without using tools.

2.2 accuracy: The nearness of a measurement to the accepted or true value.\(^\text{11}\) The accuracy is expressed as a range, about the true value, in which a measurement occurs (i.e. +/- 0.5 ppm). It can also be expressed as the % recovery of a known amount of analyte in a determination of the analyte (i.e. 103.5 %).

Note – Accuracy is getting a result that is close as possible to the correct result. With a sample made up to a Chlorine Standard of 1.00 ppm then the result from the kit should be as close as possible to 1.00 ppm within the constraints of the kit. This is a useful measure and what customers may be interested in when they want to know about the performance of a test method.

2.4 agitation: Mechanical or manual movement to dislodge filter aid and dirt from the filter element.

2.4 air assist backwash: A compression of air in the filter effluent chamber using an air compressor or water pressure from the recirculating pump. When released, it rapidly decompresses and forces water in the filter tank through the elements in reverse direction to dislodge the filter aid and accumulated dirt and carry them to waste.

2.4.2 service factor amps: The current, in amperes, under the service factor horsepower at rated volts.

2.4.3 service factor horsepower: The motor data plate horsepower multiplied by the data plate service factor.

2.2 analyte: Parameter that is a subject of the water analysis such as pH or free chlorine.

2.x **backwash**: Flow of water through filter element(s) or media in a reverse direction to dislodge accumulated dirt and/or filter aid and remove them from the filter tank.

2.x **backwash cycle**: The time required to backwash the filter system thoroughly.

2.x **backwash rate**: The rate of application of water through a filter during backwash expressed in liters / minute / square meter (U. S. gallons / minute / square foot) of effective filter area.

2.x **body feed**: Continuous addition of controlled amounts of filter aid during operation of a diatomite-type filter to maintain a permeable filter cake. If added as a slurry, this may be referred to as slurry feed.

2.x **bromine**: A chemical that works as a sanitizer or disinfectant to kill bacteria and algae in pool and spa water.

2.x.x **combined bromine**: Bromine that has combined with ammonia, nitrogen or other organic compounds.

2.x.x **free bromine**: The active form of bromine that is available to kill bacteria and algae.

2.x.x **total bromine**: the sum of the amount of free bromine and combined bromine.

2.x **cartridge**: A depth- or surface-type filter component with fixed dimensions, designed to remove suspended particles from water flowing through the unit.

2.x.1 **depth-type cartridge**: A filter cartridge with media relying on penetration of particles into the media for removal and providing adequate holding capacity of such particles.

2.x.2 **surface-type cartridge**: A filter cartridge with media relying on retention of particles on the surface of the cartridge for removal.

2.x **challenge water**: See 2.x, "test solution."

2.x **chemical feed rate indicator**: A mechanism that will create reproducible results expressed in units of weight or volume of chemical per unit of time or per unit of volume of water. The mechanism may be a direct reading instrument or may require the use of a reference chart.

2.x **chemical feeder output rate**: The weight or volume of active ingredients delivered by a chemical feeder expressed in units of time.

2.x **chlorine**: A chemical that works as a sanitizer or disinfectant in pool and spa water to kill bacteria and algae, and oxidizes ammonia and nitrogen compounds such as swimmer waste.

2.x.x **combined chlorine**: Chlorine that has combined with ammonia, nitrogen or other organic compounds.

2.x.x **free chlorine**: The active form of chlorine available to kills bacteria and algae.

2.x.x **total chlorine**: The sum of the amount of free chlorine and combined chlorine.

2.x **cleaning**: The physical removal of soiling materials.

2.x.1 **easily cleanable**: Fabricated of materials, designed and constructed so that soil is removed by normal (non-mechanical) cleaning methods.
2.x contaminant: Undesirable organic and inorganic, soluble and insoluble substances in water including microbiological organisms.

2.x corrosion-resistant: Capable of maintaining original surface characteristics under prolonged contact with the use environment.

2.x cover mounting ring: A fitting containing a recess located in the deck to receive the cover of a surface skimmer.

2.x filter design flow rate: The flow rate of a filter determined by multiplying the total effective filter area by the allowable filtration rate, expressed in liters/minute (U.S. gallons/minute).

2.x diatomite filter element: A device in a filter tank used to trap solids and convey water to a manifold, collection header, pipe, or similar conduit. Filter elements usually consist of a septum and septum support.

2.x disinfection: The killing of pathogenic agents by chemical or physical means directly applied.

2.x sand-type filter distribution system

2.x.1 upper distribution system (influent): Devices used to distribute water entering a sand-type filter to prevent movement or migration of the filter media. This type of system also collects water during filter backwashing unless other means are provided.

2.x.2 lower distribution system (underdrain [effluent]): Devices in the bottom of a sand-type filter used to collect water uniformly during filtering and to distribute the backwash water uniformly.

2.x effluent: The treated stream emerging from a unit, system, or process.

2.x electrolytic chlorinator: A device that converts dissolved chloride salt (sodium chloride) into chlorine and its reaction products.

2.x equalizer line: An automatically operating line from below the pool surface to the body of a skimmer, designed to prevent air being drawn into the filter when the water level drops below the skimmer inlet.

2.x filter aid: A finely divided medium (e.g., diatomaceous earth, processed perlite) used to coat a septum of a diatomite-type filter.

2.x filter media: The material that separates particulate matter from the water passing through.

2.x filtration cycle (filter run): The operating time between filter cleanings.

2.x filter, cartridge-type: A pressure or vacuum-type device designed to filter water through one or more cartridges.

2.x filter, diatomite-type: A pressure or vacuum-type device designed to filter water through a thin layer of filter aid.

2.x filter, high-permeability-type: A pressure- or vacuum-type device designed to filter water through a high-permeability element.

2.x filter, sand-type: A device designed to filter water through sand or an alternate sand-type media. The filtration process may be done under pressure, under vacuum, or by gravity.
2.x.1 **standard rate (rapid rate):** Design filtration rate not greater than 122 L/min/m² (3 gal/min/ft²) for public pools, spas, or hot tubs, and not greater than 203 L/min/m² (5 gal/min/ft²) for residential pools, spas, or hot tubs.

2.x.2 **high rate:** Design filtration rate greater than 203 L/min/m² (5 gal/min/ft²) for public and residential pools, spas, or hot tubs.

2.x **filtration rate:** The flow rate of water through a filter expressed in liters / minute / square meter (gallons / minute / square foot) of the effective filter area.

2.x **flow balance valve:** A device used to regulate effluent from the skimmer housing of each of two or more surface skimmers.

2.x **flow meter:** A device that measures the rate of flow of a substance through a conduit.

2.x **freeboard:** The clear vertical distance in a sand-type filter between the top of the filter media and the lowest outlet of upper distribution system.

2.x **fresh water:** Water with a specific conductivity less than that of a solution containing 600 mg/L of sodium chloride.

2.x **friction loss:** A pressure drop, expressed in meters (feet) of water or kPa (psi), caused by liquid flowing through the piping and fittings. (Friction loss tables may be used to estimate the actual friction loss in a system.)

2.x **head loss:** The total pressure drop in kPa (psi) or meters (feet) of water (head) between the inlet and outlet of a component.

2.x.1 **maximum design head loss (filters):** The maximum head loss recommended by the manufacturer for a clean filter at a specific flow rate.

2.x **high-permeability element:** Mechanically interlocked, nonwoven filter material designed to remove suspended solids.

2.x **hydrogen peroxide:** A compound consisting of two atoms of hydrogen and two atoms of oxygen (H₂O₂) usually supplied in an aqueous solution.

2.x **influent:** The water stream entering a unit, system, or process.

2.x **level 1 (L1):** Accuracy and repeatability performance level of a water testing device. Refer to section N.6 Accuracy Testing.

2.x **level 2 (L2):** Accuracy and repeatability performance level of a water testing device. Refer to section N.6 Accuracy Testing.

2.x **level 3 (L3):** Accuracy and repeatability performance level of a water testing device. Refer to section N.6 Accuracy Testing.

2.x **multiport valve:** A device used to direct flow to, through, and from a swimming pool, spa, or hot tub filter, which usually replaces conventional valves and face piping on a filter.
2.x net positive suction head (NPSH): The head available at the entrance or eye of an impeller to move and accelerate water entering the eye. This is the gauge pressure at the suction flange of pump plus velocity head.\(^{12}\)

2.x.1 NPSH available (NPSHA): A function of the system in which the pump operates. Available NPSH must be at least equal to the required NPSH at the desired flow rate.

2.x.2 NPSH required (NPSHR): The value supplied by the pump manufacturer, based on the pump design.

2.x operating range: The range within which a WQTD shall function. Evaluation of WQTD may have specified operating ranges for various analytes or parameters. Operating ranges for evaluation may include water temperature (70-102°F), pH (6-9), total (combined) chlorine (0-10 ppm), free chlorine (1-10 ppm), total hardness as CaCO\(_3\) (0-1,000 ppm), total alkalinity (buffering) the pH as CaCO\(_3\) (0-300 ppm), etc. The operating range is used to determine the make up of the various test solutions used in this evaluation procedure.

2.x ozone: A gas consisting of three atoms of oxygen (O\(_3\)).

2.x ozone generator: A device that causes ozone to be formed.

2.x pH: A figure expressing acidity or alkalinity, where 7 is neutral, higher values are more acidic and lower values are more alkaline.

2.x positive displacement: Mechanical displacement of fluid.

2.x.1 alternate sand-type media: Granular material(s) specified to be used instead of sand in a sand-type filter.

2.x power: Brake horsepower input required to operate pumps.

2.x precision: The numerical agreement between two or more measurements using the same test equipment.\(^{13}\) The precision can be reported as the range for a measurement (difference between the minimum and maximum results). It can also be reported as the standard deviation or the relative standard deviation. It is a measure of how close together the measurements are, not how close they are to the correct or true value.

Note – The precision can be very good and the accuracy very dire. This is a useful measure of the performance of a test method. Precision is getting the same result each time you perform the test. Precision is not accuracy. You can be precisely wrong but are consistently wrong.

2.x precoat: A layer of filter aid on the septum of a diatomite-type filter at the beginning of a filter cycle.

2.x process equipment: Equipment used for on-site generation and/or application of ozone, ultraviolet light/hydrogen peroxide, copper and silver ions, or chlorine.

2.x pump discharge pressure: The actual gauge reading taken at the discharge of a pump, expressed in kPa (psi).

\(^{12}\) See 6.6 for pump performance curve requirements.

2.x removable: Capable of being taken away from the main unit using only simple tools (e.g., screwdriver, pliers, and open-end wrench).

2.x.1 readily removable: Capable of being taken away from the main unit without using tools.

2.x reagent: A solid, liquid or gas component of a WQTD that is state chemical used to condition a sample or that reacts with a test parameter as part of a test procedure to create various challenge solutions.

2.x reagent grade: A “laboratory” or highly purified grade of chemical.

2.x repeatability: The within-run precision.\(^\text{14}\)

2.x reproducibility: The between-run precision.\(^\text{15}\)

2.x resolution: The smallest discernible difference between any two measurements that can be made.\(^\text{16}\) For meters this is usually how many decimal places and significant figures are displayed (i.e. 0.01). For titrations and various comparators it is the smallest interval the device is calibrated or marked to (i.e. 1 drop = 10 ppm, 0.2 ppm for a Direct Read Titrination (DRT), or ± half a unit difference for an octaslide or color chart). Note that the resolution may change with concentration or range. In some cases the resolution may be less than the smallest interval, if it is possible to make a reading that falls between calibration marks. This is often done with various comparators.

Note – Resolution is receiving a result in increments which are small in relation to the range of measurement. For example there is little point in trying to measure two dots on a piece of paper that are 6 inches apart with a ruler that is only marked in 1 foot increments. There would not be much improvement if you had a ruler marked in 3 inch increments. At the very minimum the ruler should be marked with 1 inch increments to give you a practical answer that is usable.

One caveat is that resolution has very little relationship to accuracy or precision. The resolution will always be less than the accuracy or precision however it is not a statistical measure of how well a method of analysis works. The resolution can be very good and the accuracy and precision can be very dire. This is not a useful measure of the performance of a test method.

2.x run: A run is a single data set, from set up to clean up. Generally, one run occurs on one day. However, for meter calibrations, a single calibration is considered a single run or data set, even though it may take 2 or 3 days.

2.x self-priming centrifugal pump: A pump (after initial filling with water) capable of priming and repriming a dry suction line (up to 3 m [10 ft] vertical lift) without using foot or check valves or adding water.

2.x sensitivity: The resolution based on how this term is used in some catalogs. This term is not listed in any of the references. Sometimes it is used for detection limit. It is a confusing term and should be avoided. (see resolution definition)


\(^{16}\) Statistics in Analytical Chemistry: Part 7 – A Review, D. Coleman and L Vanatta, American Laboratory, Sept 2003, p. 34.
**2.x septum:** Part of a diatomite-type filter element consisting of cloth, wire screen, or another porous material on which filter aid is deposited.

**2.x skimmer cover:** A device or lid to close the deck opening to the skimmer housing.

**2.x skimmer equalizer pipe:** A connection from skimmer housing to the pool, spa, or hot tub below the weir, sized to satisfy pump demand and prevent air lock.

**2.x skimmer equalizer valve:** A device on the equalizer line that opens when the water level inside skimmer tank drops below operating level, and that remains closed during normal skimming.

**2.x skimmer housing:** A structure that attaches to or contains a skimmer weir, strainer basket, and other devices used in the skimming operation.

**2.x skimmer weir assembly:** A floating device over which water from the pool, spa, or hot tub passes during skimming, along with its means of guiding or attachment to the skimmer.

**2.x slurry feed:** See 2.x, “body feed.”

**2.x spa / hot tub:** A unit that is not usually drained, cleaned, or refilled for each individual. This term may include, but is not limited to, hydrojet circulation, hot water or cold water mineral baths, air induction bubbles, or any combination thereof.

**2.x spray rinse, manual:** A spray system used manually for washing filter aid and/or accumulated dirt from the filter surface either in place or after removal from the filter tank (usually by a hose and nozzle).

**2.x spray rinse, mechanical:** A fixed or mechanically movable spray system that directs a stream of water against the filter surface and causes the filter aid and/or accumulated dirt to dislodge.

**2.x static suction lift:** The vertical distance in meters (feet) from center line of the pump impeller to pool water level.

**2.x strainer basket:** A readily removable, perforated, or otherwise porous container used to catch coarse material.

**2.x supporting material:** Material used to support filter media in a sand-type filter.

**2.x test solution:** The liquid used to conduct a particular test or challenge.

**2.x total dynamic head:** The arithmetic difference between total discharge head and suction head. (A vacuum reading is considered a negative pressure.) This value is used in developing the performance curve.

**2.x.1 total discharge head:** The static discharge head, plus the discharge velocity head, plus the friction head in the discharge line.

**2.x.2 total suction head:** The static suction head minus the friction head in the suction line.

**2.x total dynamic suction lift (TDSL):** The arithmetic total of static suction lift, friction head loss, and velocity head loss on the suction side of the pump.

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17 See 6.6 for pump performance curve requirements.
2.x toxic: Having an adverse physiological effect on humans.

2.x trimmer valve: A flow-adjusting device used to proportion flow between the skimming weir and main suction line, from the main outlet, or from the vacuum cleaning line.

2.x turbidity: A measurement of suspended particulate matter in water expressed as nephelometric turbidity units (NTU).

2.x turnover rate: The time required to recirculate the entire volume of water in a swimming pool, spa, or hot tub.

2.x ultraviolet light: The segment of the light spectrum between 100 and 300 nanometers (nm).

2.x ultraviolet unit: A device that produces ultraviolet light between 250 and 280 nm for the purpose of inactivation of microorganisms by UV radiation.

2.x user: Any person using a pool, spa, or hot tub and adjoining deck area for the purpose of water sports, recreation, or related activities.

2.x vacuum: Pressure lower than atmospheric pressure.

2.x vacuum cleaner connection: A connection used to attach a hose for cleaning.

2.x Water quality testing device (WQTD): A product designed to measure the level of a parameter in swimming pool or spa/hot tub water. A WQTD includes a device or method to provide a visual indication of parameter level, and may include one or more reagents and accessory items.

2.x.x electronic water quality test device: A device that requires power supply (such as line current or a battery) to yield a result.

2.x.x non-electronic water quality test device: A device that does not require a power supply (such as line current or a battery) to yield a result.

2.x working pressure: The maximum operating pressure recommended by manufacturer.

2.x zeolite: Hydrated aluminosilicates that contain sodium, potassium, magnesium, and calcium.

17 Water Quality Testing Devices

17.1 General

Water quality testing devices are used to monitor and measure recreational water parameters to help maintain the optimal swimming environment. Products covered by this section include test strips used with or without an electronic comparator, chemical (liquid or powder) kits with or without electronic comparators, and analytical probes as well as other products or technologies, to cite a few examples.
17.2 Testing

WQTD units selected for testing shall be from at least 2 different batches or manufacturing runs. Products are conditioned as appropriate per the manufacturer’s instructions then exposed and tested per annex N requirements to various test solutions to evaluate their accuracy, repeatability, reproducibility, and shelf life, within specified use ranges.

17.2.1 Temperature of room used for testing

Testing will be conducted at laboratory ambient air temperature and humidity with the stock and test solutions noted in annex N.

17.2.2 Temperature of solution used for testing

The WQTD will be tested at one or both solution temperatures of pool and spa as noted in annex N.1.1.2 and based upon the manufacturer’s recommendation.

17.2.3 pH testing

The WQTD that tests pH shall meet the requirements of annex N. The WQTD shall be used to analyze test solutions within each range shown in N.6.1 if the range includes a pH within the operating range of the WQTD. The test solutions shall be tested three times at each pH with each unit of the WQTD under test. All test points shall be used to determine accuracy. The data points for each unit shall determine repeatability; each unit shall comply with the requirement in N.6.1. The data shall be compared between units to determine reproducibility.

17.2.4 Chlorine (free and combined) testing

A WQTD that tests free and combined chlorine shall meet the applicable accuracy, repeatability and reproducibility standards from N.6.2 when the WQTD is tested in accordance with N.4 or N.5. An L1 WQTD shall be tested at the low, middle, and high points of the operating range of the WQTD for free and combined chlorine as specified by the manufacturer. L2 and L3 WQTD’s shall be tested with test solutions with a concentration in each one of the applicable ranges in N.6.2. The test solutions shall be tested three times at each concentration with each unit of the WQTD under test. All the test points shall be used to determine accuracy. The data points of each unit shall determine repeatability; each unit shall comply with the requirement in N.6.2.

17.2.5 Bromine testing

A WQTD that tests bromine shall meet the applicable accuracy, repeatability, and reproducibility standard from N.6.3 and N.7. The manufacturer shall specify the level (L1, L2 or L3) of the WQTD. An L1 WQTD shall be tested at the low, middle, and high points of the operating range of the WQTD for bromine as specified by the manufacturer. An L2 WQTD shall be tested with test solutions with a bromine concentration in each one of the ranges specified in N.6.3 if the range is within the operating range of the WQTD. The test solutions shall be tested three times at each bromine concentration with each unit of the WQTD under test. All the test points shall be used to determine accuracy. The data points for each unit shall determine repeatability; each unit shall comply with the requirements in N.6.3. The data shall be compared between units to determine reproducibility.

17.2.6 Accuracy within Operating Range (Level 1, 2, and/or 3)

Testing will be conducted based upon the manufacturers recommended/claimed use range and the operating ranges to evaluate conformance with level L1, L2, and/or L3 requirements for each parameter.
17.2.7 Repeatability (or Precision) and Reproducibility

Test two or more lots of production to verify production lot variability and consistency in product performance.

To assess reproducibility, testing of the two separate lots should occur with separate test solutions made on different days.

17.2.8 Shelf Life

The shelf life for the reagents and components of a WQTD shall be at least as long as specified by the manufacturer when the reagents and components are tested in accordance with N.8. When tested with reagents and components stored for the manufacturer specified shelf life, the accuracy, repeatability, and reproducibility of the WQTD shall be within 10% of the initial accuracy, repeatability, and reproducibility. Testing for shelf life will occur upon sample used for qualification testing to verify claim and product performance. Product will be stored in accordance with manufacturer’s instructions. After initial testing and storage, the product will be tested to verify compliance with requirements.

17.3 Operation and use instructions

The manufacturer shall provide operation and use instructions with the WQTD. The instructions shall address:
- WQTD components
- WQTD conditioning, if applicable.
- Detailed use instructions, including:
  - Sample size
  - Reagent(s) required and measurement of reagents.
  - Addition of reagent(s) and mixing.
  - Wait times, if applicable.
  - Method of determining test result, including calculation and conversion factors, as applicable.
- Maintenance of WQTD components, if applicable.
- Proper storage of the WQTD and its components.

Operation and use instructions shall be furnished by the manufacturer for testing the product. The instructions shall address the following:
- Proper conditioning
- Proper handling and use technique
- Model number of unit
- Operation and maintenance instructions
- Applicable caution statements

17.4 WQTD Marking/Identification

The WQTD shall have identification or marking that is permanent, easy to read, and securely attached to the unit. The identification or marking shall contain:
- Manufacturer’s name and address
- Model number of the unit
- Parts list to facilitate the identification and ordering of replacement parts
- WQTD classification level (L1, L2, L3)

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Annex N
(normative)

Test Method for Water Quality Testing Devices

N.1 Test Solution

N.1.1 Purpose:

This annex gives instruction for the testing of test strips, color comparator, titration, and electronic Water Quality Test Devices (WQTD) commercially available for determining water chemistry in swimming pools and spas.

In general, synthetic pool water of specific characteristics (Alkalinity, pH, Calcium Hardness and TDS) is prepared using DI water and reagent grade chemicals. Any of the above parameters or additional parameters (such as chlorine) are modified by addition or omission of known amounts of chemical. The concentration or value of the test solution is verified by approved analytical methods and the results compared to the WQTD result.

WQTD’s with fixed working ranges, such as indicator strips or color comparators will be tested at three points within the working range specified by the manufacturer’s instructions. One test is near the low end of the range, one near the middle, and one near the high end. The lowest and highest concentrations tested should be at least one increment of measure (for that test system) away from the test system minimum and maximum.

WQTD’s with theoretically very wide ranges (such as titration kits) shall be checked at one point below and one point above the optimum concentration for each parameter.

N.1.1.2 Temperature for the test solution

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<table>
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<tbody>
<tr>
<td>Pool Temp</td>
<td>27° ± 1°C (80° ± 2°F)</td>
</tr>
<tr>
<td>Spa Temp</td>
<td>39° ± 1°C (102° ± 2°F)</td>
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Unless otherwise noted, the solutions for testing shall be at both the Spa Temperature and Pool Temperature. If a manufacturer only claims functionality for Pool or Spa, testing may be conducted at just that temperature and testing and listing noted as such. Otherwise, testing must be conducted at both solution temperatures due to specific water chemistry parameters and product related variables having an impact on results. Test solution temperature shall be maintained throughout each test of a WQTD.

N.1.1.3 Synthetic Pool Water Characteristics

Unless otherwise noted, testing at the following water conditions must be conducted due to specific water chemistry parameters and product related variables having an impact on results. (Note: These specifications only apply to parameters that are not being varied for test purposes.)

- Alkalinity: 80-120 ppm as CaCO₃ (Adjusted with NaHCO₃)
• Ca Hardness: 200-250 ppm CaCO$_3$ (Adjusted with CaCl$_2$.H$_2$O)
• TDS: 1000-1500 ppm (Adjusted to this level with NaCl)
• pH: 7.4-7.6 (Adjust with HCl or NaOH)

N.2 Stock Solution Preparation

1. Sodium Bicarbonate Solution: Dissolve 16.8 g of NaHCO$_3$ in about 500 ml DI water and dilute to one liter. 10 ml of this solution added to one liter will result in alkalinity of 100 ppm as CaCO$_3$, prior to pH adjustment.

2. Calcium Chloride Solution: Dissolve 14.7 g CaCl$_2$.2H$_2$O in about 500 ml DI water and dilute to one liter. 10 ml of this solution added to one liter will result in Ca hardness of 100 ppm as CaCO$_3$.

3. Sodium Chloride Solution: Dissolve 100 g NaCl in 500 ml DI water and dilute to one liter. Each ml added to one liter will increase TDS by 100 ppm.

4. Chlorine Stock Solution: Dilute 1 ml of Clorox bleach to 100 ml. Determine actual Chlorine concentration by dilution and amperometric titration or DPD methods.

5. Ammonium Chloride solution-Dissolve 0.1 g NH$_4$Cl in 100 ml DI water.

N.3 pH Test

Note - Always prepare a volume of pool water to allow for not only the test system check at each sample point, but also for verification testing. Two liters of water is typically sufficient.

N.3.1 pH Test Procedure

Determine the pH levels for the test in accordance with 17.2

a) Adjust the general test water pH using HCl or NaOH to the highest level to be tested as measured by the lab meter (when adjusting pH using HCL, alkalinity may be consumed; do not permit the alkalinity to go out of range). The pH at each level shall be maintained within ± 0.2 units throughout the test.

b) If required, each unit of the WQTD under test shall be conditioned or calibrated in accordance with the manufacturer's instructions.

c) A sample of the test solution as required by the WQTD shall be taken and analyzed with one of the WQTD units under test in accordance with the manufacturer's instructions. The pH shown by the lab meter at the time the sample was taken and the results of the analysis shall be recorded. Another sample shall be taken and analyzed by the second unit under test. The pH shown by the lab meter at the time the sample was taken and the results of the analysis shall be recorded.

d) Repeat c) twice.

e) Adjust the pH to the next highest level using HCl and repeat c) and d).

f) Repeat e) for the third pH level and the fourth, if required.

If a WQTD is designed to measure pH in situ (a handheld pH meter or a test strip, for example), the units under test shall be used to analyze the test solutions 3 times at each pH level.

a) Adjust the general test water pH using HCl or NaOH to the highest level to be tested as measured by the lab meter. The pH at each level shall be maintained within ± 0.2 units throughout the test.

b) If required, each unit of the WQTD under test shall be conditioned or calibrated in accordance with the manufacturer's instructions.
c) The test solution shall be analyzed with the WQTD units under test in accordance with 
the manufacturer’s instructions. The units may be used simultaneously or consecutively. 
The reading from the WQTD and the reading of the lab meter shall be taken at the same 
time and recorded.
d) Clean each WQTD unit with distilled water, if necessary, and repeat c).
e) Repeat d).
f) Adjust the pH to the next highest level and repeat c), d) and e). The WQTD units may be 
reconditioned or recalibrated if required by the manufacturer’s instructions.
g) Repeat f).

N.3.2 pH Test Water

Add about 1 liter DI water to a two-liter volumetric flask. Add 20 ml NaHCO$_3$ solution, 44 ml 
CaCl$_2$.H$_2$O solution and 14 ml NaCl solution and dilute to 2 liters. This solution will have 
approximately the following characteristics:

- Alkalinity-100 ppm as CaCO$_3$
- Calcium Hardness-220 ppm as CaCO$_3$
- TDS-1100 ppm
- pH-8.3

— Transfer the pool water into a two-liter beaker and place on stir plate. Set the stir speed 
to medium and leave at this speed for the remainder of the pH test.

— Calibrate a laboratory pH meter/electrode per manufacturer’s instructions, typically with 
pH 7.0, pH 4.0 and pH 10 buffers. Place the calibrated pH electrode in the stirring water 
and allow stabilization. The solution should read about pH 8.3.

— Determine the first (highest) pH value to be tested. If the point is greater than pH 8.3, 
adjust pH up with 0.1 N NaOH. Allow the reading to stabilize at the selected point. Use 
the WQTD to determine the pH of the water. Record the pH meter reading as well as the 
test system result. Use 0.1 N HCl to lower the pH of the water to the remaining 2 test 
points, allowing the reading to stabilize prior to using the WQTD.

— Assess the results of testing based upon the resolution or sensitivity of the device.

N.3.3 Accuracy

At each pH tested, the average of the WQTD analyses at both temperatures shall meet the 
accuracy requirement in N.6.1 based on the level of the WQTD (L1, L2, or L3).

N.3.4 Repeatability

At each pH tested, the average variance in the results for each unit of a WQTD shall meet the 
repeatability requirements of N.6.1 based on the level of the WQTD.

N.3.5 Reproducibility

At each pH tested, the average result for each unit tested shall be calculated. The difference 
between the average results shall meet the reproducibility requirements of N.6.1 based on the 
level of the WQTD.

N.4 Test Procedure-Free Chlorine
Prepare two liters of synthetic pool water. Adjust pH to 7.5 with 0.1 N HCl. Experimentally determine the amount of 1:100 bleach (sodium hypochlorite) solution that will provide free chlorine concentrations at the desired test levels in the pool water.

In the case of the draft testing requirements, NSF used a Hach DR2000 with Free Chlorine Accuvac vials. However other reference water quality test devices, products or chemicals could be used (and may be further explored).

For each chlorine concentration to be tested (i.e., 1, 2, and 5 ppm), prepare enough test solution to test the WQTD and verify the free chlorine content with the DR2000. Record both the DR2000 result and the WQTD result.

Assess the results of testing based upon the resolution or sensitivity of the device.

**N.5 Test Procedure-Combined Chlorine**

Note - Combined Chlorine should be tested at a reasonable, actionable level of 0.5 ppm as whole ppm concentrations may cause interference in most DPD free chlorine determinations. Free chlorine will not be tested in the presence of combined chlorine and vice versa.

Combined chlorine is tested at one concentration level.

To test combined chlorine, add approximately 100 ml of pool water to a 200 ml volumetric flask. Add the amount of bleach solution that will result in a chlorine concentration of 0.5 ppm in 200 ml. Add 1 ml of ammonium chloride solution and mix. Wait 10 minutes and dilute to 200 ml. Mix.

Use the Hach Free Chlorine Accuvac vials to verify free Cl is less than 0.05 ppm. Use Hach Total Chlorine Accuvac vials to confirm total chlorine concentration. Use the WQTD to determine combined chlorine and record both the DR2000 results and the WQTD result.

Assess the results of testing based upon the resolution or sensitivity of the device.

**N.6 Accuracy Testing**

**N.6.1 Accuracy levels for pH**

<table>
<thead>
<tr>
<th>Range of operation</th>
<th>Accuracy limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 to 10 (optimum 6.8 to 8.4)</td>
<td>+/- 0.2 pH</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>L1</th>
<th>Between 5.0 and 6.2</th>
<th>+/- 0.2 pH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Between 6.2 and 7.2</td>
<td>+/- 0.2 pH</td>
</tr>
<tr>
<td></td>
<td>Between 7.2 and 7.8</td>
<td>+/- 0.2 pH</td>
</tr>
<tr>
<td></td>
<td>Between 7.8 and 8.4</td>
<td>+/- 0.2 pH</td>
</tr>
<tr>
<td></td>
<td>Between 8.4 and 10.0</td>
<td>+/- 0.2 pH</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>L2</th>
<th>Between 5.0 and 6.2</th>
<th>+/- 0.4 pH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Between 6.2 and 7.2</td>
<td>+/- 0.2 pH</td>
</tr>
<tr>
<td></td>
<td>Between 7.2 and 7.8</td>
<td>+/- 0.2 pH</td>
</tr>
<tr>
<td></td>
<td>Between 7.8 and 8.4</td>
<td>+/- 0.2 pH</td>
</tr>
<tr>
<td></td>
<td>Between 8.4 and 10.0</td>
<td>+/- 0.4 pH</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>L3</th>
<th>Between 5.0 and 6.2</th>
<th>+/- 1.0 pH</th>
</tr>
</thead>
</table>
### N.6.2 Accuracy levels for Chlorine; free and combined

#### Range of operation 0 to 10 ppm

**Note** - Optimum is 0 to 5 ppm for free chlorine and less than 0.5 ppm for combined chlorine.

<table>
<thead>
<tr>
<th>L1</th>
<th>Between 0 and 10</th>
<th>+/- 0.1</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>L2</th>
<th>Between 0 and 1</th>
<th>+/- 0.25</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Between 1 and 3</td>
<td>+/- 0.5</td>
</tr>
<tr>
<td></td>
<td>Between 3 and 5</td>
<td>+/- 1.0</td>
</tr>
<tr>
<td></td>
<td>Between 5 and 10</td>
<td>+/- 2.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>L3</th>
<th>Between 0 and 1</th>
<th>+/- 0.25</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Between 1 and 3</td>
<td>+/- 0.5</td>
</tr>
<tr>
<td></td>
<td>Between 3 and 5</td>
<td>+/- 1.0</td>
</tr>
<tr>
<td></td>
<td>Between 5 and 10</td>
<td>+/- 2.5</td>
</tr>
</tbody>
</table>

### N.6.3 Accuracy levels for Bromine total, free, and combined

#### Range of operation 0 to 10 ppm (optimum)

<table>
<thead>
<tr>
<th>L1</th>
<th>Between 0 and 10</th>
<th>+/- 0.2</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>L2</th>
<th>Between 0 and 3</th>
<th>+/- 0.5</th>
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<tbody>
<tr>
<td></td>
<td>Between 3 and 6</td>
<td>+/- 1.0</td>
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<tr>
<td></td>
<td>Between 6 and 10</td>
<td>+/- 2.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>L3</th>
<th>Between 0 and 6</th>
<th>+/- 1.0</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Between 6 and 10</td>
<td>+/- 2.0</td>
</tr>
</tbody>
</table>

### N.7 Repeatability or Precision Testing

Conduct testing on product from two (or more) separate lots of production. The results from testing two (or more) separate lots of product shall be within the acceptable range. If one of the products achieves less accuracy in the water chemistry testing, the lesser of the results will be considered the result for the product.

### N.8 Shelf Life Testing

To verify shelf life, open or use product as required for the above testing. Upon completion of use of product close/seal/turn off, and store in accordance with manufacturers instructions or store at 50% relative humidity at 23 °C ± 4 °C (73 °F ± 8 °F) for the duration of the shelf life. After the shelf life time has elapsed, open/turn on etc. and conduct testing with the product for the appropriate product types or parameters. If product does not comply, the manufacturer must revise shelf life claims, storage conditions, etc. as appropriate.