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. The accuracy can be 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.x agitation: Mechanical or manual movement to dislodge filter aid and dirt from the filter element.

2.x 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.x amps: The current, in amperes, under the motor data plate horsepower at rated volts.

2.x.1 maximum load amps: The maximum current, in amperes, under the service factor horsepower at -10% of the rated voltage.

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

2.x.1 non-electronic (water quality test equipment): A device that doesn’t require a power supply (such as line current or a battery) to yield a result.

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 performance level of water testing device. Refer to section N.6 Accuracy Testing.

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

2.x level 3 (L3): Accuracy performance level of 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 the product shall function. For the purpose of testing devices, the operating range may be specified for various analytes or parameters such as: water temperature (70-102°F), pH (6-9), total (combined) chlorine (0-10 ppm), free chlorine (1-10 ppm), total hardness as CaCO₃ (0-1,000ppm), total alkalinity (buffering) the pH as CaCO₃ (0-

¹² See 6.6 for pump performance curve requirements.
300ppm), etc. The operating range is used to determine the make up of the various challenge solutions used in this evaluation procedure.

2.x ozone: A gas consisting of three atoms of oxygen (O\textsubscript{3}).

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

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.\textsuperscript{13} The precision can be reported as a range for a measurement (difference between the min and max). 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).

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 state chemical used to create various challenge solutions.

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

2.x repeatability: The within-run precision.\textsuperscript{14} 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 reproducibility: The between-run precision.\textsuperscript{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 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 DRT, or +/- half a unit difference for an octaslide or color chart). Note that the resolution many 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 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.

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.

\(^{16}\) Statistics in Analytical Chemistry: Part 7 – A Review, D. Coleman and L Vanatta, American Laboratory, Sept 2003, p. 34.
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.

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 working pressure: The maximum operating pressure recommended by manufacturer.

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17 See 6.6 for pump performance curve requirements.
2.x zeolite: Hydrated aluminosilicates that contain sodium, potassium, magnesium, and calcium.

16.12 Head loss

The manufacturer shall make available a head loss claim for systems installed into the main line. The actual head loss shall not exceed the claimed head loss by more than 10%.

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 and liquid kits with or without electronic comparators and analytical probes to cite a few examples.

17.2 Testing

Products are conditioned as appropriate per the manufacturers instructions then exposed and tested per Annex N requirements to various challenge solutions to evaluate their accuracy, repeatability, 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 challenge test solutions noted in the annex.

17.2.2 Temperature of solution used for testing

Test solution temperature will be conducted at one or both temperatures of pool and spa as noted in the annex and based upon the manufacturers recommendation/claim.

17.2.3 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.

17.2.4 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.

17.2.5 Shelf Life
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

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

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Annex N
Normative

Test Method for Water Quality Testing Devices

N.1 Test Solution

N.1.1 Purpose:

This document gives instruction for the testing of test strips, color comparator, titration, and electronic Water Quality Test Devices (henceforth referred to as WQTD’s) 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

<table>
<thead>
<tr>
<th></th>
<th>Temp</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pool Temp</td>
<td>80° +/- 2° F</td>
</tr>
<tr>
<td>Spa Temp</td>
<td>102° +/- 2° F</td>
</tr>
</tbody>
</table>

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 parameter and product related variables having an impact on results.

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 parameter 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 CaCO3 (Adjusted with CaCl2.H2O)
- 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 NaHCO3 in about 500ml DI water and dilute to one liter. 10ml of this solution added to one liter will result in alkalinity of 100 ppm as CaCO3, prior to pH adjustment.

2. Calcium Chloride Solution: Dissolve 14.7 g CaCl2.2H2O in about 500ml DI water and dilute to one liter. 10ml of this solution added to one liter will result in Ca hardness of 100 ppm as CaCO3.

3. Sodium Chloride Solution: Dissolve 100 g NaCl in 500ml 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 100ml. Determine actual Chlorine concentration by dilution and amperometric titration or DPD methods.

5. Ammonium Chloride solution: Dissolve 0.1 g NH4Cl in 100ml DI water.

N.3 Test Procedure-pH

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.

- Add about 1 liter DI water to a two-liter volumetric flask. Add 20 ml NaHCO3 solution, 44 ml CaCl2.H2O solution and 14 ml NaCl solution and dilute to 2 liters. This solution will have approximately the following characteristics:
  - Alkalinity-100 ppm as CaCO3
  - Calcium Hardness-220 ppm as CaCO3
  - TDS-1100 ppm
  - pH-8.3

- Transfer the pool water into a 2-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. 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 (For instance, 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 0.5ppm as whole ppm concentrations may cause interference in most DPD free chlorine determinations. Free chlorine will not be tested in the presence of combined chorine and vice versa.

— Combined chlorine is tested at one concentration level.

— To test combined chlorine, add approximately 100ml 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

Range of operation 5 to 10 (optimum 6.8 to 8.4)

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

<table>
<thead>
<tr>
<th>L2</th>
<th>Between 5.0 and 6.2</th>
<th>+/- 0.4pH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Between 6.2 and 7.2</td>
<td>+/- 0.2pH</td>
</tr>
<tr>
<td></td>
<td>Between 7.2 and 7.8</td>
<td>+/- 0.2pH</td>
</tr>
<tr>
<td></td>
<td>Between 7.8 and 8.4</td>
<td>+/- 0.2pH</td>
</tr>
</tbody>
</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>
<tbody>
<tr>
<td>L2</td>
<td>Between 0 and 1</td>
<td>+/- 0.25</td>
</tr>
<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>
<tr>
<td>L3</td>
<td>Between 0 and 1</td>
<td>+/- 0.25</td>
</tr>
<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>
<tbody>
<tr>
<td>L2</td>
<td>Between 0 and 3</td>
<td>+/- 0.5</td>
</tr>
<tr>
<td></td>
<td>Between 3 and 6</td>
<td>+/- 1.0</td>
</tr>
<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 2 (or more) separate lots of production. The results from testing 2 (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 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 doesn’t comply, the manufacturer must revise shelf life claims, storage conditions, etc. as appropriate.