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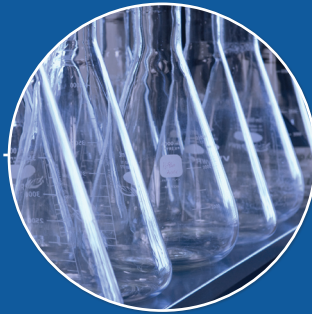
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*NSF International Standard /  
American National Standard*

## NSF/ANSI 50 - 2009a

Equipment for Swimming Pools, Spas,  
Hot Tubs and Other Recreational  
Water Facilities



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NSF International Standard/  
American National Standard

Equipment for Swimming Pools,  
Spas, Hot Tubs and other  
Recreational Water Facilities—

Evaluation criteria for materials, components,  
products, equipment and systems for use at  
recreational water facilities

Standard Developer

**NSF International**

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May 22, 2009

**American National Standards Institute**

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**The NSF Council of Public Health Consultants**

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## Foreword<sup>2</sup>

The purpose of this Standard is to establish minimum materials, design and construction, and performance requirements for components, products, equipment and systems, related to public and residential recreational water facility operation.

If a value for measurement is followed by a value in other units in parenthesis, the second value may be only approximate. The first stated value is the requirement.

In this edition of NSF/ANSI 50 the following revisions were incorporated:

### **Issue 41 and 58 – Skimmer Cleanability and Size**

The purpose of this ballot is to update section 8 regarding the sample preparation methods for UV exposure to be consistent with the additional methods developed since the 2007 version of ANSI/ASME A112.19.8 suction fitting standard method. In addition, this ballot incorporates language on the skimmer cleanability and surface skimmer fitting flow rates.

### **Issue 59 and 60 – Suction Fittings and IAPMO PS-33 reference**

The purpose of this ballot is to reference the materials safety evaluation for drains, suction fittings, and grates in section 4.1.4 and update 4.1.5 to include the cyclic pressure testing.

This Standard was developed by the NSF Joint Committee on Recreational Water Facilities using the consensus process described by the American National Standards Institute.

Suggestions for improvement of this Standard are welcome. Comments should be sent to Chair, Joint Committee on Recreational Water Facilities c/o NSF International, Standards Department, P.O. Box 130140, Ann Arbor, MI 48113-0140, USA.

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## NSF/ANSI Standard

### Equipment for Swimming Pools, Spas, Hot Tubs and other Recreational Water Facilities

Evaluation criteria for materials, components, products, equipment and systems for use at recreational water facilities

#### **1 General**

##### **1.1 Scope**

This Standard covers materials, components, products, equipment and systems, related to public and residential recreational water facility operation.

##### **1.2 Variations in design and operation**

A component varying in design and/or operation may qualify under this Standard. Appropriate tests and investigations shall indicate that the component performs as well as components conforming to this Standard. Such components shall meet the requirements for materials, finishes, and construction in this Standard.

##### **1.3 Alternate materials**

If specific materials are mentioned, other materials equally satisfactory from the standpoint of public health may be permitted.

##### **1.4 Standard review**

A complete review of this Standard shall be conducted at least every five years. These reviews shall be conducted by representatives from the industry, public health, and user groups, or agencies of the NSF Joint Committee on Swimming Pool Equipment.

##### **1.5 Normative references**

The following documents contain provisions that, through reference in this text, constitute provisions of this Standard. At the time of publication, the indicated editions were valid. All standards are subject to revision, and parties are encouraged to investigate the possibility of applying the recent editions of the standards indicated below.

AISI, *AISI type 300 series stainless steel*<sup>3</sup>

ASME, *Boiler and Pressure Vessel Code*. 2007<sup>4</sup>

ANSI/ASME A112.19.17 (2002). *Safety Vacuum Release Systems (SVRS) for Residential & Commercial Swimming Pool, Spa, Hot Tub, Wading Pool Suction System*<sup>2</sup>

ANSI/ASME A112.19.8 2007 (R1996). *Suction Fittings for Use in Swimming Pools, Wading Pools, Spas, Hot Tubs, and Whirlpool Bathtub Appliances*<sup>4</sup>

ANSI/ASME B40.100 – 2005. *Pressure Gauge and Gauge Attachments*<sup>4</sup>

APHA, *Standard Methods for the Examination of Water and Wastewater*, twentieth edition<sup>5</sup>

ASTM F 2387 (2004). *Standard Specification for Manufactured Safety Vacuum Release Systems (SVRS) for Swimming Pools, Spas and Hot Tub*<sup>6</sup>

ASTM C136-2006: *Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates*, 2004<sup>6</sup>

ASTM, D 3739 2006. *Standard Practice for Calculation and Adjustment of the Langelier Saturation Index for Reverse Osmosis*<sup>6</sup>

ASTM E11-04: *Standard Specification for Wire Cloth Sieves for Testing Purposes*, 2004<sup>6</sup>

ASTM F1346-03 *Standard Performance Specification for Safety Covers and Labeling Requirements for All Covers for Swimming Pools, Spas, and Hot Tubs*.<sup>6</sup>

ASTM F2208-2008 *Standard Safety Specification for Residential Pool Alarms*<sup>6</sup>

ASTM G 154-06: *Standard Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials*<sup>6</sup>

FDA, 21 CFR 170-199. *Code of Federal Regulations*<sup>7</sup>

FDA, 21 CFR Subchapter A, Part 58. *Code of Federal Regulations*<sup>6</sup>

IAPMO, PS-33-2007a. *Flexible PVC Hose for Pools, Hot Tubs, Spa, and Jetted Bathtubs*<sup>8</sup>

Article 430 of NFPA 70, 2005. *National Electrical Code (NEC)*<sup>9</sup>

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<sup>3</sup> American Iron and Steel Institute, 410 Commonwealth Drive, Warrendale, PA 15086 [www.steel.org](http://www.steel.org)

<sup>4</sup> ASME, 3 Park Avenue, New York, NY 10016-5990 [www.ASME.org](http://www.ASME.org)

<sup>5</sup> American Public Health Association, 800 I Street NW, Washington, DC 2000 [www.APHA.org](http://www.APHA.org)

<sup>6</sup> ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2859 [www.ASTM.org](http://www.ASTM.org)

<sup>7</sup> USFDA, 5600 Fishers Lane, Rockville, MD 20857 [www.fda.gov](http://www.fda.gov)

<sup>8</sup> IAPMO, 5001 E. Philadelphia St. Ontario, CA 91761 [www.iapmo.org](http://www.iapmo.org)

<sup>9</sup> National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269 [www.NFPA.org](http://www.NFPA.org)

NSF/ANSI 14. *Plastics piping system components and related materials*

NSF/ANSI 42. *Drinking water treatment units – Aesthetic effects*

NSF/ANSI 51. *Food equipment materials*

NSF/ANSI 60. *Drinking water treatment chemicals – Health effects*

NSF/ANSI 61. *Drinking water system components – Health effects*

USEPA, 1993. *Methods for the Determination of Inorganic Substances in Environmental Samples*<sup>10</sup>

USEPA, 1990. *Methods for the Determination of Organic Compounds in Drinking Water Supplement 1*<sup>10</sup>

USEPA-600/4-79-020. *Methods for the Chemical Analysis of Water and Wastes*, March 1983<sup>10</sup>

USEPA *National Secondary Drinking Water Regulations*, 40 CFR Part 143<sup>11</sup>

USEPA *National Primary Drinking Water Regulations*, 40 CFR Part 14<sup>11</sup>

USEPA *National Primary Drinking Water Regulations*, 40 CFR Part 136<sup>11</sup>

## 2 Definitions

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

**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.<sup>12</sup> 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 %).

**2.3 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.

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

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

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

<sup>10</sup> Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402 [www.gpo.gov](http://www.gpo.gov)

<sup>11</sup> USEPA Environmental Monitoring and Support Laboratory, Cincinnati, OH 45268 [www.epa.gov](http://www.epa.gov)

<sup>12</sup> Skoog D.A., West D. M., *Fundamental of Analytical Chemistry*, 2<sup>nd</sup> ed., Holt Rinehart and Winston, Inc, 1969, p. 26.

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

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

**2.7 automated controller:** A system of at least one chemical probe, a controller, and auxiliary or integrated component, that senses the level of one or more swimming pool or spa/hot tub water parameters and provides a signal to other equipment to maintain the parameter(s) within a user-established range.

**2.8 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.

**2.9 backwash cycle:** Time required to thoroughly backwash the filter system.

**2.10 backwash rate:** 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.

**2.11 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.

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

**2.12.1 free bromine:** Bromine that has not combined with ammonia, nitrogen, or other organic compounds.

**2.12.2 total bromine:** the sum of all active bromine compounds.

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

**2.13.1 depth-type cartridge:** Filter cartridge with media relying on penetration of particles into the media for removal and providing adequate holding capacity of such particles.

**2.13.2 surface-type cartridge:** Filter cartridge with media relying on retention of particles on the surface of the cartridge for removal.

**2.14 chemical feed rate indicator:** Mechanism that will produce 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.

**2.15 chemical feeder output rate:** Weight or volume of active ingredients delivered by a chemical feeder expressed in units of time.

**2.16 chemical probe (sensor)** Component of an automated controller that monitors a given control parameter (pH, ORP, free Cl<sub>2</sub>, etc.).

**2.17 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 that can enter the pool/spa from swimmer body wastes and other sources.

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

**2.17.2 free chlorine:** Chlorine that has not combined with ammonia, nitrogen, or other organic compounds.

**2.17.3 total chlorine:** The sum of free and combined chlorine compounds.

**2.18 cleaning:** Physical removal of soiling materials.

**2.18.1 easily cleanable:** Manufactured so that dirt and debris and other soiling material may be removed by manual cleaning methods.

**2.19 contaminant:** Undesirable organic and inorganic, soluble and insoluble substances in water including microbiological organisms.

**2.20 controller:** Component of an automated controller that receives signals from chemical probes or sensors, and sends an output signal to actuate equipment.

**2.21 corrosion resistant:** Capable of maintaining original surface characteristics under prolonged contact with the use environment.

**2.22 cover mounting ring:** Fitting containing a recess located in the deck to receive the cover of a surface skimmer.

**2.23 diatomite filter element:** Device in a filter tank 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.

**2.24 disinfection:** Killing of pathogenic agents by chemical or physical means directly applied.

**2.25 effluent:** The treated stream emerging from a unit, system, or process.

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

**2.27 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.

**2.28 filter aid:** Finely divided medium (diatomaceous earth, processed perlite, etc.) used to coat a septum of a diatomite-type filter.

**2.29 filter design flow rate:** 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).

**2.30 filter media:** The material that separates particulate matter from the water passing through.

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

**2.31 filtration cycle (filter run):** Operating time between filter cleanings.

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

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

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

**2.35 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.

**2.35.1 standard rate (rapid rate):** Design filtration rate is not greater than 122 L/min/m<sup>2</sup> (3 gal/min/ft<sup>2</sup>) for public pools, spas, or hot tubs, and not greater than 203 L/min/m<sup>2</sup> (5 gal/min/ft<sup>2</sup>) for residential pools, spas, or hot tubs.

**2.35.2 high rate:** Design filtration rate greater than 203 L/min/m<sup>2</sup> (5 gal/min/ft<sup>2</sup>) for public and residential pools, spas, or hot tubs.

**2.36 filtration rate:** Flow rate of water through a filter expressed in liters/minute/square meter (gallons/minute/square foot) of effective filter area.

**2.37 flow balance valve:** Device to regulate effluent from the skimmer housing of each of two or more surface skimmers.

**2.38 flow cell:** A closed container with ports for the installation of one or more chemical probes, inlet and outlet ports for water and typically a sample port. A flow cell provides for offline installation of the chemical probes and a consistent flow of the water to be sampled.

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

**2.40 freeboard:** Clear vertical distance in a sand-type filter between top of filter media and lowest outlet of upper distribution system.

**2.41 friction loss:** 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.)

**2.42 head loss:** Total pressure drop in kPa (psi) or meters (feet) of water (head) between inlet and outlet of a component.

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

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

**2.44 hydrogen peroxide:** A compound consisting of two atoms of hydrogen and two atoms of oxygen (H<sub>2</sub>O<sub>2</sub>) usually supplied in an aqueous solution.

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

**2.46 level 1 (L1):** The highest accuracy and repeatability performance level of a water testing device. Refer to section N.6 Accuracy Testing.

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

**2.48 level 3 (L3):** The lowest accuracy and repeatability performance level of a water testing device. Refer to section N.6 Accuracy Testing.

**2.49 mg/L (ppm):** An abbreviation for milligrams per liter or parts per million, which is a concentration measurement for sanitizers and other chemical parameters such as alkalinity, calcium hardness, iron, copper, etc.

**2.50 multiport valve:** A device used to direct flow to, through, and from a swimming pool, spa, or hot tub filter and usually replaces conventional valves and face piping on a filter.

**2.51 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.<sup>13</sup>

**2.51.1 NPSH available (NPSHA):** 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.

**2.51.2 NPSH required (NPSHR):** Value supplied by the pump manufacturer, based on the pump design.

**2.52 operating range:** The range for a parameter within which a WQTD will provide acceptable accuracy as specified by the manufacturer. The operating range determines the test solutions used to evaluate the WQTD. Examples of operating ranges typical for WQTD's are: water temperature 70°-102°F (20°-50°C), pH 6.8-8.2, free and combined chlorine 0-5 ppm or 0-10 ppm.

**2.53 oxidation reduction potential (ORP):** The potential in millivolts required to transfer electrons from the oxidant to the reductant, used as a qualitative measure of the state of oxidation in water treatment. The more positive the value, the more oxidizing the solution. ORP provides a qualitative indication of the activity of the sanitizer but is not a measure of disinfectant concentration.

**2.54 ozone:** A gas consisting of three atoms of oxygen (O<sub>3</sub>).

**2.55 ozone generator:** A device that causes ozone to be formed.

**2.56 pH:** A numerical value expressing acidity or alkalinity, where 7 is neutral, higher values are more alkaline (basic) and lower values are more acidic. The numerical value is the negative base 10 log of the hydrogen ion concentration.

**2.57 pool water:** Water with a specific conductivity as shown below:

- Type 1 has a conductivity less than or equal to an aqueous sodium chloride solution of 1500 ppm.
- Type 2 has a conductivity greater than Type 1 and less than or equal to an aqueous sodium chloride solution of 6000 ppm.
- Type 3 water has a conductivity greater than Type 2.

NOTE – TDS are to include any Total Dissolved Solids that exist within makeup up or initial fill water supply.

**2.58 positive displacement:** Mechanical displacement of fluid.

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<sup>13</sup> See 6.6 for pump performance curve requirements.

- 2.59 power:** Brake horsepower input required to operate pumps.
- 2.60 precision:** The numerical agreement between two or more measurements using the same test equipment.<sup>14</sup> 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.
- 2.61 precoat:** Layer of filter aid on septum of a diatomite-type filter at beginning of a filter cycle.
- 2.62 process equipment:** Equipment used for on-site generation and/or application of ozone, ultraviolet light/hydrogen peroxide, copper and silver ions, or chlorine.
- 2.63 pump discharge pressure:** Actual gauge reading taken at the discharge of a pump, expressed in kPa (psi).
- 2.64 reagent:** A solid or liquid component of a WQTD that is used to condition a sample or that reacts with a test parameter as part of a test procedure.
- 2.65 reagent grade:** A “laboratory” or highly purified grade of chemical.
- 2.66 removable:** Capable of being taken away from the main unit using only simple tools (screwdriver, pliers, open-end wrench, etc.).
- 2.66.1 readily removable:** Capable of being taken away from the main unit without using tools.
- 2.67 repeatability:** The within-run precision.<sup>15</sup>
- 2.68 reproducibility:** The between-run precision.<sup>16</sup>
- 2.69 resolution:** The smallest discernible difference between any two measurements that can be made.<sup>17</sup> 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 Titration (DRT), or  $\pm$  half a unit difference for a color comparator or color chart).
- 2.70 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.

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<sup>14</sup> Skoog, D.A., West, D. M., *Fundamental of Analytical Chemistry*, 2<sup>nd</sup> ed., Holt Rinehart and Winston, Inc, 1969, p. 26.

<sup>15</sup> Jeffery G. H., Basset J., Mendham J., Denney R. C., *Vogel's Textbook of Quantitative Chemical Analysis*, 5<sup>th</sup> ed., Longman Scientific & Technical, 1989, p. 130.

<sup>16</sup> Jeffery G. H., Basset J., Mendham J., Denney R. C., *Vogel's Textbook of Quantitative Chemical Analysis*, 5<sup>th</sup> ed., Longman Scientific & Technical, 1989, p. 130.

<sup>17</sup> Statistics in Analytical Chemistry: Part 7 – A Review, D. Coleman and L Vanatta, American Laboratory, Sept 2003, p. 34.

**2.71 sand-type filter distribution system**

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

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

**2.72 self-priming centrifugal pump:** 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.

**2.73 septum:** Part of a diatomite-type filter element consisting of cloth, wire screen, or other porous material on which filter aid is deposited.

**2.74 set point:** The user established target level of a parameter (pH, ORP, etc.) to be maintained by an automated controller.

**2.75 skimmer cover:** Device or lid to close deck opening to the skimmer housing.

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

**2.75.2 skimmer equalizer valve:** Device on the equalizer line that opens when water level inside skimmer tank drops below operating level and remains closed during normal skimming.

**2.75.3 skimmer housing:** Structure that attaches to or contains skimmer weir, strainer basket, and other devices used in the skimming operation.

**2.75.4 skimmer weir assembly:** 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.

**2.76 slurry feed:** Refer to body feed definition (see 2.8).

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

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

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

**2.80 static suction lift:** Vertical distance in meters (feet) from center line of the pump impeller to pool water level.

**2.81 strainer basket:** Readily removable, perforated, or otherwise porous container to catch coarse material.

**2.82 supporting material:** Material to support filter media in a sand-type filter.

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

- 2.84 total dynamic head:** 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.
- 2.84.1 total discharge head:** The static discharge head, plus the discharge velocity head, plus the friction head in the discharge line.
- 2.84.2 total suction head<sup>18</sup>:** The static suction head minus the friction head in the suction line.
- 2.84.3 total dynamic suction lift (TDSL):** Arithmetic total of static suction lift, friction head loss, and velocity head loss on suction side of pump.
- 2.85 toxic:** Having an adverse physiological effect on humans.
- 2.86 trimmer valve:** 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.
- 2.87 turbidity:** A measurement of suspended particulate matter in water expressed as nephelometric turbidity units (NTU).
- 2.88 turnover rate:** The time required to recirculate the entire volume of water in a swimming pool, spa, or hot tub.
- 2.89 ultraviolet light:** The segment of the light spectrum between 100-300 nanometers (nm).
- 2.90 ultraviolet unit:** A device that produces ultraviolet light between 250-280 nm for the purpose of inactivation of microorganisms by UV radiation.
- 2.91 user:** Any person using a pool, spa, or hot tub and adjoining deck area for the purpose of water sports, recreation, or related activities.
- 2.92 vacuum:** Pressure lower than atmospheric pressure.
- 2.92.1 vacuum cleaner connection:** Connection to attach a hose for cleaning.
- 2.93 water quality testing device (WQTD):** A product designed to measure the level of a parameter. 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.
- 2.93.1 electronic water quality test device:** A device that requires power supply (such as line current or a battery) to yield a result.
- 2.93.2 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.
- 2.94 working pressure:** Maximum operating pressure recommended by manufacturer.
- 2.95 zeolite:** Hydrated aluminosilicates that contain sodium, potassium, magnesium, and calcium.

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<sup>18</sup> See 6.6 for pump performance curve requirements.

### 3 Materials

#### 3.1 General

Materials shall not sustain permanent damage or deformation when subject to repeated handling associated with the routine operation and maintenance of the equipment.

#### 3.2 Material formulation

Materials intended to be in contact with swimming pool or spa/hot tub water shall not impart undesirable levels of contaminants or color to the water, as determined in accordance with annex A. The following items are exempt from the material review procedures described in annex A:

- swimming pool and spa/hot tub components with a surface area less than 650 cm<sup>2</sup> (100 in<sup>2</sup>) in direct contact with water;
- swimming pool components with a mass less than 40 g (1.4 oz);
- spa/hot tub components with a mass less than 2 g (0.07 oz);
- components made entirely from materials acceptable for use as a direct or indirect food additive in accordance with 21 CFR 170-199 (Food and Drugs);
- coatings and components made from materials acceptable for use in contact with potable water in accordance with NSF/ANSI 14 (potable water material requirements), NSF/ANSI 42, NSF/ANSI 51, or NSF/ANSI 61. In order to be qualified under NSF/ANSI 14, 42 or 61 the surface area to water volume ratio of the intended use conditions should meet the requirements of NSF/ANSI 61 when evaluated to the total allowable concentration (TAC) requirements of the standard; and
- treatment chemicals that conform to the requirements of NSF/ANSI 60.

#### 3.3 Corrosion resistance

Materials intended to be in contact with swimming pool or spa/hot tub water shall be corrosion-resistant under use conditions or shall be rendered corrosion-resistant by a protective coating. Cathodic protection may be used to improve the corrosion resistance of a material. High-speed parts requiring close tolerances are not required to be corrosion-resistant.

The following materials are considered to have acceptable corrosion resistance for general swimming pool and spa/hot tub equipment applications and are not required to have a protective coating:

- non-ferrous alloys containing not less than 58% copper;
- nickel-copper alloy – Monel 400 (UNS N04400);
- AISI<sup>19</sup> type 300 series stainless steel;
- thermoplastics and thermoset plastics; and
- concrete.

When used in pumps and strainers, cast iron is not required to have a protective coating.

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<sup>19</sup> American Iron and Steel Institute, 410 Commonwealth Drive, Warrendale, PA 15086 [www.steel.org](http://www.steel.org)

### 3.4 Dissimilar metals

Dissimilar metals not normally compatible on the electromotive scale shall not be in direct contact with one another (except for sacrificial anode service).

### 3.5 Insulating fittings

Insulating fittings shall be provided when piping material is not compatible (on the electromotive scale) with adjoining fittings or parts of the circulation system. Such fittings shall be electrically nonconductive and shall conform to the applicable requirements of 3.1 and 3.2.

### 3.6 Piping materials

**3.6.1** Galvanized steel pipe and galvanized iron pipe with cast or malleable iron fittings and bronze or iron-bodied bronze fitted valves are acceptable for use without a protective coating. If such materials have a steel housing, then no insulating fittings are required. Otherwise, all metal pipe with a dissimilar metal housing shall have insulated fittings.

**3.6.2** Piping intended for use in water applications with a conductivity greater than or equal to 600 ppm shall be made from one of the following materials:

- aluminum brass (UNS C68700);
- copper-nickel, 10% (UNS C70600);
- copper-nickel, 30% (UNS C71500);
- nickel-copper alloy - Monel 400 (UNS N04400); or
- thermoplastics or thermoset pipes conforming to the applicable sections of NSF/ANSI 14.

## 4 Design and construction

This section contains general requirements that apply to all equipment covered under the scope of this Standard.

### 4.1 Mechanical parts

#### 4.1.1 Installation of piping, valves, and fittings

If circulation system components are not supplied with the required piping, valves, and fittings installed, the manufacturer shall provide a piping diagram, a parts list, and installation procedures.

#### 4.1.2 Assembly

Piping assemblies shall be capable of being disassembled for maintenance and repair.

#### 4.1.3 Closing and sealing devices

Mechanical clamps, gaskets, and sealing devices shall not leak when subjected to the applicable pressure requirements.

#### 4.1.4 Suction fittings

Suction fittings that are designed to be totally submerged for use in swimming pools and spa/hot tubs shall comply with ANSI/ASME A112.19.8 and the material requirements of Section 3 of this standard.

#### 4.1.5 PVC Hose

Helix or fabric reinforced flexible PVC hose, for use on circulation piping in pools, hot tubs, spas, and jetted bathtub units, shall comply with the following:

- IAPMO PS-33;
- the material requirements of Section 3; and
- Annex B.1.5 after a 20,000 cycle strength test conducted in accordance with Annex B.1.4.

#### 4.1.6 Safety Vacuum Release Systems (SVRS)

Manufactured Safety Vacuum Release Systems (SVRS) shall comply with ASTM F 2387 and/or ASME A112.19.17 and the material requirements of Section 3 of this standard.

#### 4.1.7 Pool and Spa Covers

All pool or spa covers (safety or otherwise) shall be labeled in accordance with ASTM F1346 and shall conform to the requirements of section 3 and 4 of this standard.

#### 4.1.8 Pool Alarms

Pool Alarms shall comply with ASTM F2208, as well as the material requirements of section 3 of this Standard.

#### 4.2 Electrical components

Electrical components shall conform to the applicable requirements of the National Electrical Code (NEC).

### 5 Filters

#### 5.1 General

The requirements in this subsection apply to diatomite-type, sand-type, cartridge-type and high-permeability-type filters.

##### 5.1.1 Filter tanks (pressure service)

**5.1.1.1** The working pressure of a pressure service filter shall be 345 kPa (50 psi) or greater. The design burst pressure of a pressure service filter tank shall be at least four times the working pressure (i.e., minimum safety factor = 4:1).

**5.1.1.2** The filter tank and its integral components shall not rupture, leak, burst, or sustain permanent deformation when subject to the following conditions in accordance with annex B, section B.1:

- a hydrostatic pressure equal to 1.5 times the working pressure for 300 s;
- 20,000 consecutive low-high pressure cycles; and
- a hydrostatic pressure equal to two times the working pressure.

NOTE – As noted in annex B, leaking from integral components such as valves and fittings that may occur when the hydrostatic pressure is increased to two times the working pressure does not constitute nonconformance to this requirement.

Filter tanks designed, constructed, evaluated, and stamped with the appropriate Code Symbol Stamp, in accordance with the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section VIII or X, shall be exempt from this requirement.

### **5.1.2 Filter tanks (vacuum service)**

**5.1.2.1** The design collapse pressure of a vacuum service filter tank shall be at least 1.5 times the pressure developed by the weight of the water in the tank (i.e., minimum safety factor = 1.5).

**5.1.2.2** Vacuum service filter tanks whose inlets may be closed during filter operation shall not rupture, leak, collapse, or sustain permanent deformation when subjected to a vacuum of 85 kPa (25 in Hg) for 300 s in accordance with annex B, section B.2.

### **5.1.3 Internal components**

**5.1.3.1** Internal components of a pressure service filter shall not sustain damage or deformation that may affect water flow characteristics when the filter is operated in accordance with the manufacturer's instructions and when operated under the test conditions in annex B.

**5.1.3.2** Internal components of a vacuum service filter shall not sustain damage or deformation that may affect water flow characteristics when the filter is operated in accordance with the manufacturer's instructions and when operated under the test conditions in annex B.

**5.1.3.3** Filter element components of a filter designed for pressure backwashing shall not sustain damage or permanent deformation when exposed to the pressure differential developed during backwashing operations.

### **5.1.4 Initial head loss**

The head loss through a filter operating at the design flow rate shall not exceed the manufacturer's maximum design head loss when determined in accordance with annex B, section B.3.

### **5.1.5 Accessibility**

Filter components requiring service shall be accessible for inspection and repair when installed in accordance with the manufacturer's instructions. Covers on openings required for access into the filter tank shall be removable.

### **5.1.6 Drains**

A filter shall have a drain so that the filter tank may be drained in accordance with the manufacturer's winterizing instructions.

### **5.1.7 Air release**

If the filter permits accumulation of air in the top of the filter tank, the filter tank shall have an automatic air release at the top of the tank. A manual air release valve shall also be provided.

### **5.1.8 Cleaning of filter media**

The cleaning of filter media in accordance with the manufacturer's instructions shall render the filter media and elements free of visible dirt and debris. The head loss through the filter after cleaning the media shall not exceed 150% of the initial head loss through the filter. The head loss through the filter

after cleaning shall not exceed the manufacturer's maximum design head loss. Testing shall be conducted in accordance with annex B, section B.4.

### 5.1.9 Turbidity reduction

A filter shall reduce water turbidity by 70% or more when tested in accordance with annex B, section B.5.

## 5.2 Diatomite and other precoat media-type filters

The requirements in this subsection apply only to pre-coat media-type filters utilizing diatomite or other pre-coat filter media (that conforms to 5.2.9) and their integral components designed for the filtration of swimming pool or spa/hot tub water.

### 5.2.1 Filtration area

**5.2.1.1** The actual filtration area shall be within  $\pm 5\%$  of the effective filtration area specified on the filter data plate.

NOTE 1 – For leaf or disc-type precoat media-type filters, the effective filtration area is equal to the total surface area of all septa minus the combined area of all septum support members wider than 6.4 mm (0.25 in) in contact with the septum during filtration.

NOTE 2 – For tube-type precoat media-type filters, the effective filtration area is equal to the total surface area of the precoat filter media-coated tubes minus the combined area of all septum support members wider than 6.4 mm (0.25 in) in contact with the septum during filtration. The effective filtration area shall be no more than 1.5 times the total surface area of the uncoated tubes.

**5.2.1.2** For wirewound and similar-type elements, the width of septum support members shall not exceed 6.4 mm (0.25 in). The distance between adjacent septum members and the distance between adjacent openings shall not exceed 0.127 mm (0.005 in).

**5.2.1.3** Septa shall be maintained in such a position as to preclude surface contacts that reduce effective filtration area.

### 5.2.2 Turbidity limits, precoat operation

During the precoat operation, the average turbidity of the filter effluent returning to the pool or spa/hot tub shall not exceed 10 nephelometric turbidity units (NTU) over the first 60 s of flow, as determined in accordance with annex B, section B.6.

NOTE – Filters designed to refilter the effluent during the precoat operation or discharge it to waste without returning it to the pool or spa/hot tub are exempt from this requirement.

### 5.2.3 Spacing of elements

**5.2.3.1** Filters shall be designed to provide a minimum clearance between adjacent filter elements equal to the thickness or diameter of the element or 2.54 cm (1 in), whichever is less.

**5.2.3.2** The clearance between filter elements shall be sufficient to prevent contact between the septa during backwashing operations.

#### 5.2.4 Baffles

A precoat media-type filter shall have a baffle, or other water-deflecting device, that prevents incoming water from eroding the filter aid during filtration.

#### 5.2.5 Removal of waste from filter tank

A precoat media-type filter shall be designed so that wash water, dislodged filter aid, and dirt may be removed from the filter tank.

#### 5.2.6 Installation and operating instructions

The manufacturer shall provide a manual with each filter. The manual shall include operating instructions, cleaning instructions, installation instructions, design head loss curve and parts lists, and any drawings or charts necessary to permit proper installation, operation, and maintenance of the filter. The manual shall also specify the recommended amount, type, and grade of filter aid.

#### 5.2.7 Data plates(s)

5.2.7.1 A precoat media-type filter shall have a data plate(s) that is permanent, easy to read, and securely attached to the filter housing at a readily accessible location. The data plate shall contain the following information:

- manufacturer's name and address;
- filter model number;
- filter serial number;
- effective filtration area in square meters or square feet;
- required clearance (vertical and horizontal for service and maintenance);
- design flow rate in liters/minute or gallon/minute;
- working pressure, if applicable; and
- steps of operation.

The data plate shall indicate whether a filter is designed for swimming pool applications only or spa/hot tub applications only. A filter designed for both applications shall be exempt from this requirement.

5.2.7.2 If provided with the filter, each valve on the face piping of the filter shall have a permanent label or tag identifying its operation (e.g., influent, backwash, bypass).

#### 5.2.8 Filtration rate

The design filtration rate of precoat media-type filters shall not exceed the values specified in table 5.1.

**Table 5.1 – Maximum design filtration rates for precoat media-type filters**

Filter design	Intended application	Maximum design filtration rate
slurry feed	residential pool or spa/hot tub	122 L/min/m <sup>2</sup> (3 gal/min/ft <sup>2</sup> )
slurry feed	public pool or spa/hot tub	102 L/min/m <sup>2</sup> (2.5 gal/min/ft <sup>2</sup> )
no slurry feed	residential pool or spa/hot tub	102 L/min/m <sup>2</sup> (2.5 gal/min/ft <sup>2</sup> )
no slurry feed	public pool or spa/hot tub	81 L/min/m <sup>2</sup> (2 gal/min/ft <sup>2</sup> )

#### 5.2.9 Precoat filter media

Precoat media shall conform to the requirements of 3.

### 5.2.9.1 Precoat media other than diatomaceous earth (DE)

Precoat media other than DE shall also conform to the requirements of annex B, sections 3, 4, 5, 6, and 7.

## 5.3 Sand-type filters and alternate sand-type media

The requirements in this subsection apply only to sand-type filters and their integral components designed for the filtration of swimming pool or spa/hot tub water.

### 5.3.1 Upper distribution system (influent)

Components of the influent distribution system shall be designed so that they do not become clogged during filtration. The system shall distribute incoming water during the filter cycle to prevent appreciable movement or migration of filtering media at the design flow rate.

### 5.3.2 Lower distribution system (effluent)

Components of the effluent distribution system shall be designed so that they do not become clogged during filtration. The system shall provide adequate flow and distribution to expand the filtering bed uniformly during backwashing.

### 5.3.3 Accessibility of internal components

Internal filter components shall be accessible through an access opening in the filter tank. Filters having dome-type or similar underdrains with openings at least 4.8 mm (0.189 in) wide are exempt from this requirement.

### 5.3.4 Filter media

**5.3.4.1** Filter sand shall be hard, silica-like material that is free of carbonates, clay, and other foreign material. The effective particle size shall be between 0.40 mm (0.016 in) and 0.55 mm (0.022 in), and the uniformity coefficient shall not exceed 1.75. Filters intended for use with an alternate media that does not conform to these requirements shall specify the alternate media on the data plate. The filter and the alternate media shall conform to the other applicable requirements of this Standard.

**5.3.4.2** If a different media is used to support the filter media, it shall be rounded material that is free of limestone and clay and installed according to the manufacturer's instructions. When the support media and the filter media are installed in accordance with the manufacturer's recommendations, the filter media shall not intermix with the support media when operated and backwashed at least three cycles in accordance with annex B, section B.4.

#### 5.3.4.3 Alternate sand-type media

A material that is marketed or claimed to replace sand directly as a filter media in a sand-type filter shall conform to 3.2, 5.1.8, 5.1.9, 5.3.4.3, and 5.3.5 when tested in a representative sand-type filter in accordance with annex B, sections B.3, B.4 and B.5.

**5.3.4.3.1** The manufacturer of an alternate sand-type media shall specify the particle size and uniformity coefficient for the media. Particle size and uniformity coefficient shall be confirmed in accordance with ASTM C136 with sieves conforming to ASTM E11.

**5.3.4.2.2** The filtration rate and backwash rate for an alternate sand-type media shall be as specified in 5.3.9.

### 5.3.5 Filter media behavior

**5.3.5.1** Filter media shall not be removed during backwashing at a rate of 610 L/min/m<sup>2</sup> (15 gal/min/ft<sup>2</sup>) or the manufacturer's recommended backwash rate.

**5.3.5.2** Media shall be capable of being thoroughly cleaned when backwashed following the manufacturer's recommendations.

**5.3.5.3** Filter media and supporting material shall not migrate during the filtration cycle. The filter bed shall remain level during the filtration cycle when operated at the design flow rate. The maximum difference between the highest and lowest elevations on the surface of the filter bed shall not exceed the values shown in table 5.2.

**Table 5.2 – Maximum difference in media surface elevations on a sand type filter**

Filter diameter (D) <sup>1</sup>	Maximum elevation difference
< 0.9 m (36 in)	76 mm (3 in)
0.9 to 1.6 m (36 to 63 in)	0.083 x D
> 1.6 m (63 in)	135 mm (5.25 in)

<sup>1</sup> For filters with non-circular surface geometry, D shall equal the maximum horizontal dimension on the media surface.

**5.3.5.4** Filter media and supporting material shall not impart color to the water during filter operation.

**5.3.5.5** The filter bed of a pressure service filter shall not break down or channel when subjected to a pressure differential of 103 kPa (15 psi) or the maximum recommended by the manufacturer, whichever is greater. The filter bed of a vacuum service filter shall not break down or channel when subjected to a pressure differential of 54 kPa (16 in Hg) or the maximum recommended by the manufacturer, whichever is greater.

### 5.3.6 Installation and operating instructions

**5.3.6.1** The manufacturer shall provide a manual with each filter. The manual shall include operating instructions, installation instructions, cleaning instructions, design head loss curve and parts lists, and any drawings or charts necessary to permit proper installation, operation, and maintenance.

**5.3.6.2** The manufacturer of an alternate sand-type media shall provide written instructions for the installation of the media in a filter, including requirements for a different support media; for any specific preparation of the media for operation; and for the operation of filter with the alternate sand-type media.

### 5.3.7 Data plates(s)

**5.3.7.1** A sand-type filter shall have a data plate(s) that is permanent, easy to read, and securely attached to the filter plant at a readily accessible location. The data plate shall contain the following information:

- manufacturer's name and address;
- filter model number;
- filter serial number;
- effective filtration area in square meters or square feet;
- required clearance (vertical and horizontal for service and maintenance);
- design flow rate in liters/minute or gallons/minute;
- design backwash flow rate in liters/minute or gallons/minute;

- working pressure;
- suitability for buried installation;
- steps of operation;
- filtration rate in L/min/m<sup>2</sup> or gal/min/ft<sup>2</sup>; and
- special media specifications, if any, as required in 5.3.4.1.

The data plate shall indicate whether a filter is designed for swimming pool applications only or spa/hot tub applications only. A filter designed for both applications is exempt from this requirement.

**5.3.7.2** If provided with the filter, each valve on the face piping of the filter shall have a permanent label or tag identifying its operation (e.g., influent, backwash, bypass).

### 5.3.8 Effective filtration area

The actual filtration area shall be within  $\pm 5\%$  of the effective filtration area specified on the filter data plate.

NOTE – The actual filtration area is equal to the total area of the filter media bed minus the combined area of any obstructions (e.g., pipes, headers, air lines) wider than 6.4 mm (0.25 in) passing through the surface of the filter media bed.

### 5.3.9 Filtration and backwash rates

**5.3.9.1** The design filtration rate of sand-type filters shall conform to the limits specified in table 5.3.

**Table 5.3 – Design filtration rates for sand type filters**

Filter design	Intended application	Design filtration rate
rapid rate	residential pool or spa/hot tub	max: 204 L/min/m <sup>2</sup> (5 gal/min/ft <sup>2</sup> )
rapid rate	public pool or spa/hot tub	max: 122 L/min/m <sup>2</sup> (3 gal/min/ft <sup>2</sup> )
high rate	residential pool or spa/hot tub	min: 204 L/min/m <sup>2</sup> (5 gal/min/ft <sup>2</sup> ) max: 813 L/min/m <sup>2</sup> (20 gal/min/ft <sup>2</sup> )
high rate	public pool or spa/hot tub	min: 204 L/min/m <sup>2</sup> (5 gal/min/ft <sup>2</sup> ) max: 813 L/min/m <sup>2</sup> (20 gal/min/ft <sup>2</sup> )

**5.3.9.2** The design backwash rate shall be a minimum of 610 L/min/m<sup>2</sup> (15 gal/min/ft<sup>2</sup>).

## 5.4 Cartridge-type and high-permeability-type filters

The requirements in this subsection apply only to cartridge-type and high-permeability-type filters and their integral components designed for the filtration of swimming pool or spa/hot tub water.

### 5.4.1 Clearance

The clearance between the filter tank and cartridge(s) or high-permeability element(s) shall be at least 6.4 mm (0.25 in). The clearance between adjacent cartridges shall be at least 6.4 mm (0.25 in).

### 5.4.2 Baffles

A filter shall have a baffle or other flow-deflecting device that prevents influent water from flowing directly against the effective filter area during filtration.

#### 5.4.3 Trash screen (vacuum service cartridge filters)

Vacuum service cartridge filters shall have a trash screen at the filter inlet to remove large debris such as leaves and paper from the influent water before it reaches the filter cartridges.

#### 5.4.4 Cartridge alignment (stacked multi-cartridge filters)

Stacked cartridges shall be securely fastened to one another. They shall be aligned to ensure a proper seal and to maintain the required clearance between adjacent cartridges. Devices used to align cartridges shall not obstruct the filtration area.

#### 5.4.5 Removal of waste from filter tank

A filter shall be designed so that wash water and dislodged dirt may be removed from the filter tank.

#### 5.4.6 Removal of cartridges

Cartridges shall be readily removable. If cartridge stacks are so long that lower cartridges cannot be removed by hand, the manufacturer shall provide a device for lifting them out of the filter tank.

#### 5.4.7 Installation and operating instructions

The manufacturer shall provide a manual with each filter. The manual shall include operating instructions, cleaning instructions, installation instructions, design head loss curve and parts lists, and any drawings or charts necessary to permit proper installation, operation, and maintenance. The manual shall also include the recommended size, number, and type of cartridges or high-permeability elements. If the reuse or replacement of cartridges or high-permeability element is recommended, the manufacturer shall provide printed removal and cleaning instructions.

#### 5.4.8 Data plates(s)

5.4.8.1 A filter shall have a data plate that is permanent, easy to read, and securely attached to the filter housing at a readily accessible location. The data plate shall contain the following information:

- manufacturer's name and address;
- filter model number;
- filter serial number;
- effective filtration area in square meters or square feet;
- required clearance (vertical and horizontal for service and maintenance);
- design flow rate in liters/minute or gallons/minute;
- working pressure;
- steps of operation; and
- recommended replacement cartridge or high-permeability element.

The data plate shall indicate whether a filter is designed for swimming pool applications only or spa/hot tub applications only. A filter designed for both applications is exempt from this requirement.

5.4.8.2 If provided with the filter, each valve on the face piping of the filter shall have a permanent label or tag identifying its operation (e.g., influent, backwash, bypass).

#### 5.4.9 Filtration area

The actual filtration area shall be within  $\pm 5\%$  of the effective filtration area specified on the filter data plate.

NOTE – The actual filtration area is equal to the total surface area of the cartridge or element material minus the combined area of any obstructions wider than 6.4 mm (0.25 in) in direct contact with the cartridge/element material during filtration.

#### 5.4.10 Filtration rates

5.4.10.1 The design filtration rate of a cartridge-type filter shall not exceed the maximum values specified in table 5.4.

**Table 5.4 – Maximum design filtration rates for cartridge-type filters**

Filter design	Intended application	Maximum design filtration rate
depth-type	residential pool or spa/hot tub	325 L/min/m <sup>2</sup> (8 gal/min/ft <sup>2</sup> )
depth-type	public pool or spa/hot tub	122 L/min/m <sup>2</sup> (3 gal/min/ft <sup>2</sup> )
surface-type	residential pool or spa/hot tub	41 L/min/m <sup>2</sup> (1 gal/min/ft <sup>2</sup> )
surface-type	public pool or spa/hot tub	15 L/min/m <sup>2</sup> (0.375 gal/min/ft <sup>2</sup> )

The design filtration rate of a high-permeability-type filter intended for use with a residential pool or spa/hot tub shall not exceed 407 L/min/m<sup>2</sup> (10 gal/min/ft<sup>2</sup>).

## 6 Centrifugal pumps

This section contains requirements for centrifugal pumps used to circulate swimming pool or spa/hot tub water in commercial and residential applications. The requirements for strainers shall apply to strainers that are integral with the pump and to strainers supplied as separate equipment for use in conjunction with a centrifugal pump.

### 6.1 General

6.1.1 Pumps shall operate with minimum adjustment. Required adjustments to the power supply shall be acceptable.

6.1.2 Sections of the pump that may require inspection or service shall be accessible.

6.1.3 Moving parts shall be covered.

6.1.4 Replacement parts shall fit the pump without a need to redrill or otherwise alter the pump or replacement part.

### 6.2 Hydrostatic pressure test

Parts of a pump that contain water under pressure shall be capable of withstanding a hydrostatic pressure test at 150% of the working pressure.

### 6.3 Strainers

6.3.1 Strainers shall be designed so that solids will not bypass the strainer basket during normal operation nor drop into the strainer pot when the strainer basket is removed for cleaning.

6.3.2 Strainer baskets shall be readily removable and easily cleanable.

6.3.3 Openings in the strainer basket shall not exceed 0.3 cm<sup>2</sup> (0.05 in<sup>2</sup>) in area.

**6.3.4** The ratio of the open area in the strainer basket to the cross-sectional area of the strainer inlet connection shall be 4:1 or greater. The open area in the strainer basket shall be no less than 65 cm<sup>2</sup> (10 in<sup>2</sup>).

**6.3.5** Strainers with an inlet connection with a nominal pipe size of 1.5 in or less shall have a strainer basket with a minimum internal volume of 410 cm<sup>3</sup> (25 in<sup>3</sup>). Strainers with an inlet connection with a nominal pipe size of 2 in or greater shall have a strainer basket with a minimum internal volume of 1475 cm<sup>3</sup> (90 in<sup>3</sup>).

**6.3.6** Strainer covers shall be designed to be opened manually and shall have a gasket that creates a tight seal when tightened by hand.

**6.3.7** A non-integral strainer shall have sufficient drain holes with plugs to drain the strainer body without disconnecting the strainer.

**6.3.8** The manufacturer of a non-integral strainer shall specify the maximum flow rate for which the strainer is intended and shall provide a curve showing the head losses in the intended range of flow rates.

NOTE – This information is necessary to facilitate the proper matching of a pump and strainer.

#### **6.4 Drain plugs**

A pump shall have sufficient drain holes with plugs to drain the pump housing and strainer body (if applicable) without disconnection of the pump or its parts.

#### **6.5 Shaft seals**

The pump shaft shall be sealed by packing or a mechanical seal. If packing is used, there shall be a means for its periodic lubrication. Instructions on maintenance and lubrication shall be provided.

#### **6.6 Pump performance curve**

**6.6.1** For each pump model or model series, the manufacturer shall provide a pump performance curve that plots the pump's total dynamic head versus the discharge flow rate. The manufacturer shall also have a curve available that plots the net positive suction head (NPSH) or total dynamic suction lift (TDSL), brake horsepower, and pump efficiency in relation to the performance curve.

NOTE – Pumps with a rating of 5 HP (3.7 kW) or less are not required to have a NPSH curve.

**6.6.2** The actual pump curve, as determined in accordance with annex C, section C.1, shall be within a range of -3% to +5% of the total dynamic head or -5% to +5% of the flow, whichever is greater, indicated by the performance curve. Data taken above 90% full flow shall not be judged to the acceptance criteria.

#### **6.7 Operation and installation instructions**

**6.7.1** The manufacturer shall provide a manual with each pump. The manual shall include written instructions for the proper installation, operation, and maintenance of the pump. Instructions shall include a parts list and diagrams to facilitate the identification and ordering of replacement parts. If the parts list does not uniquely identify each part for ordering, the manufacturer shall also supply the appropriate specification numbers and serial numbers, and the impeller diameter.

**6.7.2** A pump manufactured without an integral strainer shall state in its installation instructions, on a data plate, or on an attached label that the pump is to be installed with a strainer conforming to the requirements in this Standard.

## 6.8 Self-priming pumps

A pump designated as self-priming shall be capable of repriming itself when operated under a suction lift without the addition of more liquid. Self-priming capability shall be verified in accordance with annex C, section C.3.

## 6.9 Data plates(s)

**6.9.1** A pump shall have a data plate(s) that is permanent; easy to read; and securely attached, cast, or stamped into the pump at a location readily accessible after installation. The data plate(s) shall contain the following information:

- manufacturer's name and address;
- pump model number;
- pump serial number, date code, or specification number;
- whether the unit has been evaluated for swimming pools or spas/hot tubs, if not evaluated for both applications; and
- designation as a self-priming or non-self-priming pump. If the pump is self-priming the maximum vertical lift height shall be specified.

**6.9.2** The proper direction of impeller rotation shall be clearly indicated by an arrow on the data plate, on a separate plate, or cast onto the pump.

## 6.10 Motors

**6.10.1** Motors shall be open-drip-proof or totally enclosed. They shall be constructed electrically and mechanically to perform satisfactorily under the end-use conditions.

**6.10.2** Motors shall be capable of operating a pump under full load with a voltage variation of  $\pm 10\%$  from data plate rating.

**6.10.3** Single-phase motors with a power rating less than 2.24 kW (3 HP) shall have built-in thermal overloads to provide locked rotor and running protection. All other motors shall have:

- built-in thermal overload protection;
- magnetic line starters with overload relays; or
- installation instructions specifying that magnetic line starters with overload relays shall be provided upon installation.

**6.10.4** Each motor shall have a permanent data plate(s) that contains the following information:

- motor manufacturer's name and address;
- model number;
- power rating (kilowatt or horsepower, or both);
- speed;
- voltage;
- frequency;
- phase;

- service factor;
- maximum load amps or full load amps (service factor amps);
- serial number or date code, or both;
- frame size;
- temperature rise;
- time rating; and
- statement of thermal protection.

## 7 Multiport valves

This section contains requirements for multiport valves used on filters in public and residential swimming pools and spas/hot tubs. The requirements apply to the housing, valve, handle, and other components that are integral parts of the multiport valve.

### 7.1 General

**7.1.1** Multiport valves and component parts that may require inspection and service shall be accessible.

**7.1.2** Multiport valves shall be marked or keyed for proper assembly and operation.

**7.1.3** Multiport valves shall be designed so that parts may be replaced without drilling or otherwise altering the multiport valve or replacement part.

### 7.2 Positive indexing

**7.2.1** Multiport valves shall be marked so that the position of the operating handle clearly indicates each operation.

**7.2.2** Multiport valves shall be designed so that the position of the operating handle can only be changed intentionally.

**7.2.3** Multiport valves shall be designed so that the operating handle can be properly realigned if removed.

### 7.3 Design pressure

Multiport valves shall be designed to have a burst pressure of at least four times the working pressure (i.e., minimum safety factor = 4:1).

### 7.4 Hydrostatic pressure

The multiport valve and its integral components shall not rupture, leak, burst, or sustain permanent deformation when subjected to a hydrostatic pressure of 1.5 times the working pressure (see annex D, section D.1).

## 7.5 Valve leakage

Multiport valves, when operating at the working pressure and maximum design flow rate, shall show no signs of leakage from the waste port. When operated in the backwash position, leakage from the return-to-pool port shall not exceed 0.0005 times the maximum design flow rate (see annex D, section D.2).

## 7.6 Head loss curve

**7.6.1** The manufacturer shall make available a head loss curve for both the filter and backwash positions.

**7.6.2** The actual head loss across a multiport valve shall not exceed the head loss indicated by the manufacturer's head loss curve by more than 10% (see annex D, section D.3).

## 7.7 Waste port seal

The valve shall show no leakage through the waste port when the valve is set in the filter position and a static pressure of up to 70 kPa (10 psi) is applied to the return port (see annex D, section D.4).

## 7.8 Identification

The multiport valve shall be clearly and permanently marked or labeled with the following:

- manufacturer name and address;
- model number;
- working pressure;
- operating setting;
- maximum head loss;
- maximum design flow rate; and
- requirements for operation at each setting and when switching between settings, e.g., the filter must be shut off prior to switching the valve position.

## 8 Recessed automatic surface skimmers

This section contains requirements for recessed automatic surface skimmers used for public and residential pools and spas/hot tubs. The requirements apply to the basic components of a surface skimmer, including the skimmer housing; strainer basket; weir; cover and mounting ring; equalizer valve or air lock protector; trimmer valve and flow balancing valves for multiple skimmer installation; and vacuum cleaner connections. Recommended procedures for the installation and operation of skimmers on public and residential pools and spas/hot tubs are provided in annex J.

### 8.1 Housing

**8.1.1** Skimmer housings whose inlets may be closed during part of operating cycle shall not sustain damage or permanent deformation when exposed to a negative pressure of 85 kPa (25 in Hg).

**8.1.2** The housing design shall allow for a smooth flow over the effective weir length.

**8.1.3** On swimming pool skimmers, the housing opening at the entrance throat shall be at least 190 mm (7.5 in) wide. On spa/hot tub skimmers, the housing opening at the entrance throat shall be at least 102 mm (4 in) wide. If a circular weir is used, there shall be a clearance of at least 51 mm (2 in) between the weir lip and the side of the skimmer housing.

## **8.2 Weir**

**8.2.1** A skimmer shall have a weir that operates freely with continuous action and adjusts automatically to variations in water level over a minimum range of 102 mm (4 in), or 76 mm (3 in) if an auto-fill pool water level control device is used when operated at the maximum design flow rate (see annex E, section E.2).

**8.2.2** Flap-type weirs on swimming pool skimmers shall have a minimum unobstructed width of 184 mm (7.25 in) over the full operating range. Flap-type weirs on spa/hot tub skimmers shall have a minimum unobstructed width of 95 mm (3.75 in) over the full operating range. Flap-type weirs shall be buoyant and designed to develop an even flow over their full width. The clearance between the weir and the housing side shall not exceed 3 mm (0.125 in) at any point. Hinge construction shall preclude leakage. The weir shall be firmly attached to the housing and shall be accessible for cleaning and replacement in the field.

**8.2.3** Circular weirs shall have a minimum diameter of 102 mm (4 in). They shall be buoyant and designed to develop an even flow on the water surface around the circumference. The radial clearance between the weir float and the weir housing shall not exceed 2 mm (0.079 in). The float or basket housing shall have devices to eliminate binding. The weir shall be accessible for replacement in the field.

## **8.3 Strainer basket**

**8.3.1** A skimmer shall have a strainer basket to trap suspended and floating material in the overflow water passing through the skimmer. Spa/hot tub skimmers that have self-contained filters are exempt from this requirement.

**8.3.2** Strainer baskets shall be readily removable and easily cleanable.

**8.3.3** The area of each opening in the strainer basket shall not exceed  $0.3 \text{ cm}^2$  ( $0.05 \text{ in}^2$ ).

**8.3.4** For swimming pool skimmers, the total open area in the strainer basket shall be  $194 \text{ cm}^2$  ( $30 \text{ in}^2$ ) or greater. For spa/hot tub skimmers, the total open area in the strainer basket shall be  $71 \text{ cm}^2$  ( $11 \text{ in}^2$ ) or greater.

**8.3.5** For swimming pool skimmers, the internal volume of the strainer basket shall be  $2620 \text{ cm}^3$  ( $160 \text{ in}^3$ ) or greater. For spa/hot tub skimmers, the internal volume in the strainer basket shall be  $720 \text{ cm}^3$  ( $44 \text{ in}^3$ ) or greater.

## **8.4 Equalizer line (public pools)**

**8.4.1** A skimmer intended for public pool applications shall have an equalizer line that prevents air from becoming entrained in the suction line.

**8.4.2** When the skimmer is operating at the maximum design flow rate and the water level is lowered to 51 mm (2 in) below the lowest overflow level of the weir (see annex E, section E.2.4.e), the flow rate through the equalizer line shall be within  $\pm 5\%$  of the maximum design flow rate (see annex E, section E.4).

**8.4.3** When the skimmer is operating normally at the maximum design flow rate and up to 75% of the open area in the strainer basket is blocked, the flow rate (leakage) past the equalizer line shall not exceed 10% of the total flow rate through the skimmer (see annex E, section E.3).

**8.4.4** The equalizer line must have a cover that meets ANSI/ASME A 112.19.8.

## **8.5 Cover and mounting ring**

**8.5.1** A skimmer shall have a removable cover with a mounting ring. The cover and ring shall be free of sharp edges. The exposed surface of the cover shall be free of projections and have a permanent skid-resistant finish. A means of securing the cover in place shall be provided so that the cover cannot be dislodged, unintentionally removed, or otherwise become unstable during use.

**8.5.2** Each type and model of polymer skimmer cover shall meet the UV exposure and structural integrity requirements in 8.5.2.1 and 8.5.2.2. Type and model differences that require separate testing include shape, structure, material, color, plating, and finish. Skimmer covers that are too large to fit in the UV exposure chamber may have material bar samples molded, exposed, and tested in a manner consistent with methods developed for ANSI/ASME A112.19.8a suction fittings.

**8.5.2.1** The cover shall be exposed to ultraviolet light and water spray in accordance with ASTM G 154, using the common exposure condition, Cycle 3 found in table X2.1 of ASTM G 154 for a period of 750 hours (see annex E, section E.5.2). The sample shall experience no crazing, cracking or geometrical deformation.

**8.5.2.2** Skimmer covers that pass the UV exposure test shall be tested for structural integrity in accordance with E.5.3. A skimmer cover shall not deflect more than 9.0 mm (0.35 in), permanently deform, crack, or lose material exclusive of plating or finish when subjected to a point load of 136 kg  $\pm$  2.2 kg (300 lb  $\pm$  5 lb).

### **8.5.2.3 Requirement for evaluation of exposed ridges**

After all structural testing is completed, the covers shall be evaluated for exposed ridges. Ridges shall be considered exposed when open to the atmosphere. Exposed ridges shall conform to section 8.5.3.

## **8.5.3 Skimmer cleanability**

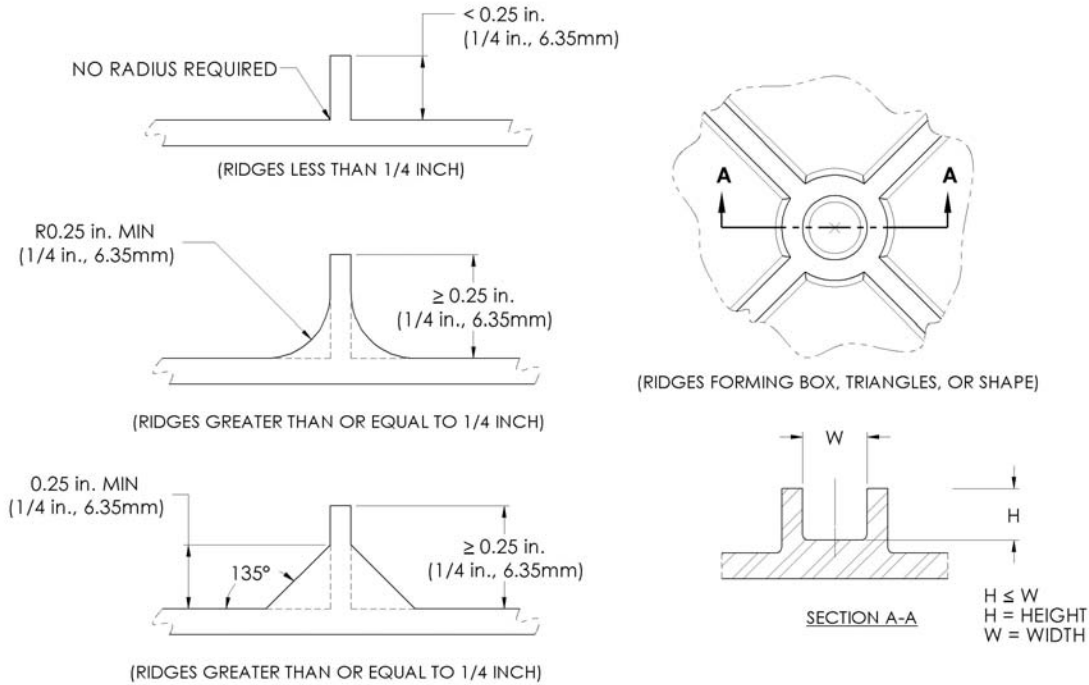
**8.5.3.1** The cover shall be designed to be easily cleanable. Covers with interior exposed structural ridges shall conform to the following. Non-exposed structural ridges are exempt from section 8.5.3.1.1, 8.5.3.1.2 and 8.5.3.1.3.

**8.5.3.1.1** Ridges with a height of less than  $\frac{1}{4}$  in are exempt from radius or fillet requirements.

**8.5.3.1.2** Ridges with a height greater than or equal to  $\frac{1}{4}$  in shall have a minimum radius of  $\frac{1}{4}$  in (0.25 in, 6.4 mm) or provide a 135 degree,  $\frac{1}{4}$  in fillet at the base of the ridges (See figure 1).

**8.5.3.1.3** Ridges forming an open box, triangle, or any shape shall not have a depth greater than the internal width of the shape.

**Figure 1 Fillet Angle for Skimmer Cleanability**



**8.6 Trimmer valves**

Trimmer valves shall not interfere with the performance of the skimmer.

**8.7 Vacuum cleaner connections**

Vacuum cleaner connections shall be in a convenient location for use and shall not interfere with normal operation of the skimmer.

**8.8 Operation and installation instructions**

**8.8.1** The manufacturer shall provide written operation and installation instructions with each unit. The instructions shall include drawings, charts, and parts lists necessary for the proper installation, operation, and maintenance of the skimmer.

**8.8.2** A skimmer equipped with an equalizer shall have, in its operation and installation instructions, a warning that the skimmer is to be installed with an equalizer wall or drain fitting conforming to ANSI/ASME A112.19.8 to prevent hair or body entrapment at the skimmer equalizer. The manufacturer may or may not supply the fitting with the skimmer.

**8.8.3** A skimmer's maximum flow rating (LPM, GPM) shall be specified based on the nominal pipe size intended to plumb the suction line (and/or equalizer line). The maximum velocity for any nominal pipe size shall not exceed 1.83 MPS (6 FPS).

## 8.9 Data plates(s)

A skimmer shall have a data plate(s) that is permanent; easy to read; and securely attached, cast, or stamped onto the cover or skimmer housing at a location readily accessible after installation. The data plate(s) shall contain the following information:

- manufacturer's name and address;
- skimmer model number;
- minimum design flow rate in liters/minute (gallons/minute); and
- maximum design flow rate in liters/minute (gallons/minute).

The data plate(s) shall indicate whether the skimmer is designed for swimming pool applications or spa/hot tub applications. A skimmer designed for both applications is exempt from this requirement. If a skimmer is intended for residential use only (see 8.4), the data plate(s) shall so indicate.

## 9 Mechanical chemical feeding equipment

This section contains requirements for mechanical chemical feeders that are used to dispense solutions, slurries, or solids in public or residential pools and spas/hot tubs. Components of mechanical feeding equipment, such as strainers, tubing connectors, and injection fittings supplied by the manufacturer as part of the chemical feed system, are also covered under this section. This section does not apply to mechanical feeding equipment that does not have adjustable output rates, mechanical feeding equipment that relies on the flow rate of water in the recirculation system, or equipment designed to feed gases.

### 9.1 General

**9.1.1** Mechanical chemical feeder parts that require cleaning and maintenance shall be accessible.

**9.1.2** The mechanical chemical feeder shall be equipped to prevent unintended siphonage or other unintended discharge of chemicals and air into a swimming pool or spa/hot tub or piping systems.

### 9.2 Erosion resistance

#### 9.2.1 Slurry feeders

When tested in accordance with the erosion resistance test described in annex F, section F.2, a slurry feeder operating at the maximum output setting shall feed an agitated suspension of diatomaceous earth 5% ( $\pm 0.5\%$ ) by volume continuously for 2500 h at  $138 \pm 3$  kPa ( $20 \pm 0.5$  psi) back pressure and shall have an output rate that is no less than 80% and no more than 120% of the manufacturer's maximum rated output. At the end of testing, the slurry feeder shall show no signs of erosion that could adversely affect proper operation.

#### 9.2.2 Dry chemical feeders

When tested in accordance with the erosion resistance test described in annex F, section F.2, a dry chemical feeder operating at the maximum output setting shall feed an applicable dry chemical continuously for 2500 h at atmospheric pressure and shall have an output rate that is no less than 80% and no more than 120% of the manufacturer's maximum rated output. At the end of testing, the dry chemical feeder shall show no signs of erosion that could adversely affect proper operation.

### 9.3 Chemical resistance

**9.3.1** When tested in accordance with the chemical resistance test described in annex F, section F.3, mechanical chemical feeders exposed to the maximum in-use concentration of the applicable chemical(s) specified for the feeder, for a test period of 100 d, shall show no signs of erosion or structural deformation.

**9.3.2** Following the 100 d chemical exposure specified in 9.3.1 and 24 h of operation at 100% output rate, mechanical chemical feeders shall conform to the uniformity of output requirements in 9.4.2.

### 9.4 Output rate

**9.4.1** Mechanical chemical feeders shall have an output rate control mechanism that is adjustable in at least four increments over the full operating range. The mechanism for regulating the output rate shall be readily accessible when the feeder is installed in accordance with the manufacturer's instructions.

**9.4.2** Mechanical chemical feeders shall deliver chemicals in slurries, solutions, or solids, at an output rate that is within  $\pm 10\%$  of feed rate indicator setting, over deliveries from 25% to 100% of the rated capacity when operated at the maximum back pressure recommended by the manufacturer (see annex F, section F.5).

### 9.5 Hydrostatic pressure

Components of a mechanical chemical feeder that normally operates under pressure shall show no evidence of rupture, leakage, burst, or permanent deformation when subjected to a hydrostatic pressure 1.5 times the manufacturer's maximum operating pressure (see annex F, section F.1).

### 9.6 Life test

**9.6.1** When tested in accordance with the life test described in annex F, section F.4, a minimum of one of three units shall complete 3000 operating hours, and a minimum of 8000 operating hours shall be accumulated among the three units. At the conclusion of the testing, the units shall perform as intended by the manufacturer and shall continue to conform to the uniformity of output requirements in 9.4.2.

**9.6.2** When tested in accordance with the life test described in annex F, section F.4, the tubing used in mechanical chemical feeders shall complete 500 satisfactory operating hours or 120% of the rated life expectancy specified by the manufacturer (whichever is greater).

### 9.7 Shielding

Moving parts of the feeder shall be covered so that no openings are exposed.

### 9.8 Motors

**9.8.1** Motors shall be continuous duty and shall conform to the requirements of Article 430 of NFPA 70, (NEC).

**9.8.2** Motors shall use standard voltages and cycles.

### 9.9 Suction lift

Positive displacement pump mechanical feeders operating with a suction lift of 1.2 m (4 ft) of water, at 80% back pressure and 100% of their rated capacity, shall deliver an output rate that is within  $\pm 10\%$  of the delivery specified by the manufacturer (see annex F, section F.6).

### 9.10 Protection against overdosing

The manufacturer shall provide printed materials warning the user of the potential for elevated chemical concentrations and hazardous gas introduction into the pool or spa. At a minimum, the printed materials shall describe the potentially hazardous conditions, such as backwash and periods of no flow in the recirculation system. The steps to be taken during installation and operation to prevent such conditions shall be included. Feeders designed to be self-draining shall be exempt from this requirement.

### 9.11 Operation and installation instructions

The manufacturer shall supply operation and installation instructions with each mechanical chemical feeder. These instructions shall include the following:

- diagrams and a parts list to facilitate the identification and ordering of replacement parts;
- installation, operation, and maintenance instructions;
- reference to flooded suction installation and prevention of cross connections;
- reference to recommended use chemicals and maximum use concentrations;
- caution statement to address potentially hazardous conditions due to chemical overdosing (see 9.10);
- reference to one or more methods to stop chemical feed automatically when no return flow to the swimming pool or hot tub exists;
- model number of the unit; and
- applicable caution statements (prominently displayed).

### 9.12 Data plates(s)

The data plate(s) on mechanical chemical feeders shall be permanent; easy to read; and securely attached, cast, or stamped onto the feeder at a location readily accessible after normal installation. Data plate(s) shall contain the following information:

- manufacturer's name and address (or prime supplier);
- feeder model and/or serial number;
- maximum operating pressure rating in kPa (psi);
- reference to installation instructions for swimming pool and hot tub/spa applications for protection against overdosing during backwash and no-flow conditions; and
- maximum output rating (volume of liquid or weight, or volume of solid chemicals, 24 h/d).

The data plate shall indicate whether the mechanical chemical feeder is designed for swimming pool applications only or spa/hot tub applications only. A mechanical chemical feeder that is designed for both applications is exempt from this requirement.

## 10 Flow-through chemical feeding equipment

This section contains requirements for adjustable output rate flow-through chemical feeders and auxiliary components used for dispensing chemicals by a flow-through process in public and residential swimming pools or spas/hot tubs. Flow-through chemical feeders without adjustable output rates and gaseous feeding equipment are not covered under 10.

### 10.1 General

Parts of the feeder requiring cleaning and maintenance shall be accessible.

### 10.2 Chemical resistance

Flow-through chemical feeders exposed to the applicable chemicals per annex G, section G.1 for a test period of 100 d shall show no signs of erosion or structural deformation.

### 10.3 Hydrostatic pressure

Flow-through chemical feeders shall show no evidence of rupture, leakage, burst, or permanent deformation when subjected to a hydrostatic pressure 1.5 times the manufacturer's maximum pressure rating (see annex G, section G.2).

### 10.4 Motors

Motors, if provided, shall be continuous duty and shall conform to the requirements of Article 430 of NFPA 70, (NEC).

### 10.5 Output rate

**10.5.1** The flow-through chemical feeder shall have an output rate control mechanism that is adjustable in at least four increments over the full operating range. The mechanism for regulating the output rate shall be readily accessible when the feeder is installed in accordance with the manufacturer's instructions.

**10.5.2** The uniformity of output for a flow-through chemical feeder shall be tested and evaluated at settings of the output rate control mechanism equivalent to 50% and 100% of the rate of maximum chemical output recommended by the manufacturer. The output of a flow-through chemical feeder shall be within  $\pm 20\%$  of the output specified by the manufacturer at each test setting of the output rate control mechanism. For each test setting, the output of the flow-through chemical feeder shall be repeatable within  $\pm 10\%$  when tested in accordance with annex G, G.3.

### 10.6 Protection against overdosing

The manufacturer shall provide printed materials warning the user of the potential for elevated chemical concentrations and hazardous gas introduction into the pool or spa. At a minimum, the printed materials shall describe the conditions that may result in such potentially hazardous conditions, such as backwash and periods of no flow in the recirculation system. The steps to be taken during installation and/or operation to prevent such conditions shall be included. Feeders designed to be self-draining shall be exempt from this requirement.

## 10.7 Flow-indicating device

**10.7.1** Flow-through chemical feeders shall be provided with a flow-indicating device on the unit, or the installation instructions shall provide for the installation of a flow-indicating device for the full range of flow rates.

**10.7.2** When the chemical output of a flow-through chemical feeder is specified relative to the flow rate of water through the feeder (i.e.,  $X \text{ m}^3/\text{hr}$  [gal/min] through the feeder =  $Y \text{ kg/d}$  [lb/d] chemical output), the chemical feeder shall be supplied with a flow-indicating device (or instructions for installing such a device) for the full range of flow rates specified by the manufacturer.

### 10.7.3 Head loss

The manufacturer shall make available a head loss claim at the maximum and minimum settings for systems installed in the main line. The actual head loss shall not exceed the claimed head loss by more than 10%.

## 10.8 Operation and installation instructions

The manufacturer shall supply the following operation and installation instructions with each flow-through chemical feeder:

- diagrams and a parts list to facilitate the identification and ordering of replacement parts;
- installation, operation, and maintenance instructions;
- model number of the unit;
- caution statement to address potentially hazardous conditions due to chemical overdosing (see 10.6); and
- caution statements regarding the recommended use chemicals (prominently displayed).

## 10.9 Data plates(s)

The data plate(s) on flow-through chemical feeders shall be permanent; easy to read; and securely attached, cast, or stamped onto the feeder at a location readily accessible after installation. The data plate(s) shall contain the following information:

- manufacturer's name and address (or prime supplier);
- feeder model (serial number optional);
- maximum output rate;
- recommended use chemical(s); and
- a caution statement indicating that the use of chemicals other than those recommended by the manufacturer may be hazardous.

The data plate shall indicate whether a flow-through chemical feeder is designed for swimming pool applications only or spa/hot tub applications only. A flow-through chemical feeder that is designed for both applications is exempt from this requirement.

## 11 General requirements for process equipment

### 11.1 Scope

Process equipment covered by this Standard in 11 through 16, for on-site generation and/or application of ozone, chlorine, bromine, ultraviolet light, and copper or copper/silver ions, may be used for treatment of swimming pool and spa/hot tub waters. Products that do not create required levels of residual disinfectant are intended for supplemental disinfection only.

NOTE – Ultraviolet-hydrogen peroxide processes are not compatible for use with diatomite-type filters.

### 11.2 Cleanability

Parts of process equipment requiring cleaning and maintenance shall be accessible.

### 11.3 Design pressure (pressure vessels)

Units and components of process equipment that are subjected to pressure shall meet a working pressure of 33 kPa (50 psi) or be equipped with a pressure-reducing valve set at the manufacturer's working pressure.

### 11.4 Flow meter

If the performance of a unit is dependent on a specified flow rate, a means to monitor and control the flow shall be provided.

### 11.5 Performance indication

The process equipment shall be provided with an effective means to alert the user when a component of this equipment is not operating.

### 11.6 Operation and installation instructions

Drawings and a parts list for easy identification and ordering of replacement parts shall be furnished with each unit and shall include:

- model number of the unit;
- instructions for proper size selection and installation;
- operation and maintenance instructions;
- a statement of the manufacturer's warranty;
- applicable caution statements (prominently displayed);
- ventilation requirements (if applicable);
- cross connection protection (if the unit is physically connected to a potable water supply); and
- a warning, if the potential exists for release of high dosages of substances that may endanger bathers.

### 11.7 Disinfection efficacy

Process equipment designed for supplemental disinfection shall demonstrate a 3 log reduction of influent bacteria when tested according to annex H.

### 11.8 Valve and component identification

All valves and performance indication devices shall have a permanent, easily legible, and conspicuous label or tag identifying their operation.

## 12 Ozone process equipment

### 12.1 General

Ozone process equipment covered by this section is intended to provide an oxidizing agent for use in circulation systems of public and residential swimming pools and spas/hot tubs. A disinfecting chemical shall be added to impart a measurable residual chemical. The measurable residual chemical shall be easily and accurately measured by a field test kit. Ozone generating equipment shall be capable of producing a quantity of ozone at a level as stated by the manufacturer, at standard conditions of generation and measurement.

### 12.2 Injection methods

Injection methods shall be designed to prevent off gassing in excess of the Occupational Safety and Health Administration (OSHA) standards for in-air ozone concentrations. Ozone levels exceeding 0.1 ppm (0.2 mg/m<sup>3</sup>) are not acceptable in the pool, spa/hot tub water when tested in accordance with annex H.

### 12.3 Life test

Process equipment shall be capable of operating 3000 continuous hours at 80% of the output rate recommended by the manufacturer.

### 12.4 Chemical resistant materials

Internal surfaces exposed to ozone shall be resistant to use application concentrations.

### 12.5 Air preparation

Systems utilizing ambient air as the source of oxygen shall be provided with an adequate air filtering and drying system to ensure that the minimum operating parameters are maintained.

### 12.6 Data plates(s)

Data plate(s) shall be permanent; easy to read; and securely attached, cast, or stamped onto the unit at a location readily accessible after normal installation. Data plate(s) shall contain the following:

- manufacturer's name and address;
- model number;
- serial number or date of manufacture;

- output rate per hour (grams per hour) at rated airflow;
- electrical requirements (volts, amps, hertz); and
- caution statements (prominently displayed) including a statement that the unit is designed for supplemental disinfection and should be used with registered or approved disinfection chemicals to impart required residual concentrations.

### **12.7 Operation and installation instructions**

In addition to the requirements specified in 11.6 and annex I, information shall be provided to the user concerning the potential for off gassing of ozone and required ozone removal devices, if applicable.

### **12.8 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%.

## **13 Ultraviolet light process equipment**

### **13.1 General**

Ultraviolet light process equipment covered by this section is intended for use in circulation systems of public and residential swimming pools and spas/hot tubs with hydrogen peroxide, chlorine, or bromine residual chemical. The residual chemical shall be easily and accurately measurable by a field test kit. If a system is used with hydrogen peroxide, a maximum concentration of 35% solution in water shall be continuously fed to maintain a minimum residual of 20 mg/L. Otherwise, these systems shall be used in conjunction with not less than 1 ppm free chlorine or 2 ppm bromine.

### **13.2 Operating temperatures**

The unit and all its components shall be designed to withstand a maximum operating temperature of  $39 \pm 1$  °C ( $102 \pm 2$  °F).

### **13.3 Operational protection**

Units shall be equipped with an automatic mechanism for shutting off the power to the ultraviolet (UV) light source whenever the cover is removed.

### **13.4 Life Test**

Ultraviolet units shall be capable of operating 3000 continuous hours at or above the manufacturers minimum rated dose. The average dose as measured by the sensor will be evaluated against the average flow rate. At least one unit shall complete 3000 h, and a minimum 8000 satisfactory hours shall be accumulated among the three units. All tests shall be carried out at  $39 \pm 1$  °C ( $102 \pm 2$  °F) for spas or hot tubs. Maintenance according to the manufacturer's instructions, except parts replacement, shall be carried out during the test period.

### **13.5 Cleaning**

For systems utilizing quartz sleeves to separate the water passing through the chamber from the UV source, the system shall be designed to permit cleaning of the lamp jackets and the sensor window or lens without

mechanical disassembly. All piping for in-place cleaning purposes shall be entirely independent of the water piping system in and out of the unit, and a drain shall be provided. The chamber shall be designed so that at least one end can be dismantled for general and physical cleaning.

**13.5.1** For systems utilizing polytetra-fluoroethylene (PTFE) surface materials to separate the water passing through the UV chamber from the UV lamps, the unit shall be designed to be readily accessible to the interior and exterior of the PTFE. The unit shall be designed to permit use of either physical or chemical cleaning methods.

### **13.6 Ultraviolet lamps**

Ultraviolet lamps shall be readily accessible for replacement, and instructions for replacement shall be provided.

### **13.7 Chemical resistant materials**

Internal surfaces exposed to direct ultraviolet light shall be resistant to use application conditions.

### **13.8 Data plates(s)**

Data plate(s) shall be permanent; easy to read; and securely attached, cast, or stamped onto the unit at a location readily accessible after normal installation. Data plate(s) shall contain the following:

- equipment name and function(s);
- manufacturer's name and address;
- model number designation;
- electrical requirements for operational volts, amps, and Hertz of the unit;
- serial number or year of construction;
- maximum rated operating pressure in kPa (psi);
- prominently displayed caution statement: "UV light is harmful to eyes and exposed skin; turn off electrical supply before opening unit.";
- caution statement that the unit is designed for supplemental disinfection and should be used with registered or approved disinfection chemicals to impart required residual concentrations.
- model and number of UV lamp(s); and
- maximum design flow rate in liters/minute (gallons/minute).

### **13.9 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%.

### 13.10 Hydrostatic Pressure Requirements

Ultraviolet light process equipment that normally operates under pressure shall show no evidence of rupture, leakage, burst, or permanent deformation when subjected to a hydrostatic pressure 1.5 times the manufacturer's maximum operating pressure (see annex F, section F.4).

## 14 In-line electrolytic chlorinator or brominator process equipment

### 14.1 General

In-line electrolytic chlorinator or brominator process equipment covered by this section is intended for use in circulation systems of public and residential swimming pools and spas/hot tubs. Equipment shall produce a quantity of sodium hypochlorite or hydrobromous acid as stated by the manufacturer.

### 14.2 Operating temperatures and pressures

If installed within the recirculating piping system, in-line electrolytic chlorinator or brominator process equipment shall be designed to withstand a maximum operating temperature of  $39 \pm 1$  °C ( $102 \pm 2$  °F) and a maximum operating pressure of 517 kPa (75 psig).

### 14.3 Operational protection

Systems shall have an automatic mechanism for shutting off the electric power to the electrolytic cell whenever one or more of the following conditions exist:

- loss of electric power to the recirculation pump; and/or
- interruption of water flow through the electrolytic cell.

#### 14.3.1 Warning devices

A visual and/or audible alarm shall be provided to warn the user when the cell voltages are not within the manufacturer's recommended range, or when the salt concentration falls below the manufacturer's recommended minimum level.

### 14.4 Chemical-resistant materials

Equipment parts shall incorporate materials that are resistant to the environment to which the parts will be subjected.

### 14.5 Output rate

The output rate shall be adjustable in at least four increments over the full operating range. Means for regulating shall be conveniently located when mounted according to the manufacturer's instructions.

#### 14.5.1 Delivery

Units shall deliver chemicals at an output rate shown by the feed rate indicator  $\pm 10\%$  of the setting, over deliveries from 25% to 100% rated capacity.

#### 14.6 Pressure requirements

Units shall meet a hydrostatic pressure of 1.5 times the manufacturer's maximum pressure rating applied to all parts of the feeder subject to pressure during operation when tested at  $39 \pm 1$  °C ( $102 \pm 2$  °F).

#### 14.7 Life test

Units shall be capable of operating 3000 continuous hours at 80% of the maximum pressure and output rate recommended by the manufacturer. Tests shall be conducted on three units using fresh water. At least one unit shall complete 3000 h, and a minimum 8000 satisfactory operating hours shall be accumulated among the three units. All tests shall be carried out in an ambient room at  $39 \pm 1$  °C ( $102 \pm 2$  °F) for spas or hot tubs. Maintenance according to the manufacturer's instructions, except parts replacement, shall be carried out during the test period.

#### 14.8 Salt level

In-line electrolytic chlorinator or brominators shall be designed to operate satisfactorily on the dissolved salt concentration range specified by the manufacturer.

#### 14.9 Data plates(s)

Data plate(s) shall be permanent; easy to read; and securely attached, cast, or stamped onto the unit at a location readily accessible after normal installation. Data plate(s) shall contain at least the following:

- equipment name;
- manufacturer's name and address;
- model number;
- electrical requirements – volts, amps and Hertz;
- serial number and/or date of manufacture;
- caution statements (prominently displayed);
- capacity or output rate; and
- salt concentration range.

#### 14.10 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%.

### 15 Brine (batch) type electrolytic chlorine or bromine generators

#### 15.1 General

Batch and process type electrolytic brine chlorine or bromine generators covered by this section are intended for use in circulation systems of public and residential swimming pools and spa/hot tubs.

#### 15.2 Operating conditions

Components of the system coming into contact with the circulated water shall be designed to withstand a maximum operating temperature of  $39 \pm 1$  °C ( $102 \pm 2$  °F) and a maximum operating pressure of 517 kPa (75 psig). Components of the system not contacting the circulating water shall be designed to withstand an ambient temperature of 49 °C (120 °F) and 100% relative humidity.

### 15.3 Injection methods

Injection methods shall be designed to prevent off-gassing in excess of the OSHA standards for in-air chlorine concentrations for both acute and long term exposure. The manufacturer shall provide certification of performance.

### 15.4 Operational protection

Systems shall have an automatic mechanism for shutting off the system to withstand support equipment failures without damage to the system. An example of system failure requiring an automatic shut-off device is interruption of water flow through the system.

#### 15.4.1 Warning devices

A visual and/or audible alarm shall be provided to warn the user when the salt concentration level falls below the manufacturer's recommended minimum level.

### 15.5 Chemical-resistant materials

Equipment parts shall incorporate materials that are resistant to the environment to which the parts will be subjected.

### 15.6 Output rate

Integrated production over a period not to exceed 12 h shall be easily adjustable or adjustable with simple tools (e.g., screwdriver, pliers, open-end wrench), in a sufficient number of increments to facilitate use. The output rate control may be accomplished by any automatic means including but not limited to:

- oxidation reduction potential (ORP) or residual chlorine sensor control switch;
- duty cycle control;
- input or output power (voltage and/or current) control; or
- a five-position switch (four settings and "off").

#### 15.6.1 Delivery

Systems shall deliver chemicals within  $\pm 20\%$  of any setting during a 12 h period and a reproducibility of  $\pm 10\%$  at any setting, over deliveries from 25% to 100% rated capacity.

### 15.7 Life test

Systems shall be capable of operating 3000 continuous hours at 80% of the maximum pressure and output rate recommended by the manufacturer. Tests shall be conducted on three units. At least one unit shall complete 3000 h, and a minimum 8000 satisfactory operating hours shall be accumulated among the three units. Maintenance according to the manufacturer's instructions, except parts replacement, shall be carried out during the test period.

### 15.8 Data plates(s)

Data plate(s) shall be permanent; easy to read; and securely attached, cast, or stamped onto the unit at a location readily accessible after normal installation. Data plate(s) shall contain at least the following:

- equipment name;
- manufacturer's name and address;
- model number;

- electrical requirements;
- serial number and/or date of manufacture; and
- capacity or maximum output rate.

## 16 Copper/silver and copper ion generators

### 16.1 General

Electrolytic copper/silver and copper ion generation systems are intended for supplemental treatment of water in public and residential pools and spas/hot tubs. These systems shall be used in conjunction with no less than 0.4 ppm free chlorine or 0.8 ppm bromine.<sup>20</sup> Copper levels shall be easily and accurately measured by a pool side test kit provided by the manufacturer. Levels of copper/silver should not be imparted into pool or spa water in excess of the USEPA Primary and Secondary National Drinking Water Regulations. The system shall conform to this Standard (see 11).

#### 16.1.1 Alternate systems

Systems using ion treatment other than copper or silver may be considered for conformance with this Standard if scientific evidence supporting the efficacy of the system is provided. Scientific evidence shall be in the following form:

- published peer-reviewed literature;
- data supporting conformance of the system to the requirements of this section;
- data supporting the efficacy of the system in an actual field application(s); or
- rationale supporting the efficacy of the system for the intended end use.

#### 16.2 Operating temperatures and pressures

The system shall be designed to withstand a minimum water temperature of  $39 \pm 1$  °C ( $102 \pm 2$  °F).

#### 16.3 Warning devices

A visual or audible indicator shall be provided to warn the user when ion production ceases.

#### 16.4 Chemical-resistant materials

Equipment parts shall incorporate materials that are resistant to the environment to which the parts will be subjected.

#### 16.5 Output rate

Integrated production over a period not to exceed 12 h shall be easily adjustable or adjustable with simple tools (e.g., screwdriver, pliers, open-end wrench) in a sufficient number of increments to facilitate use, including but not limited to:

- duty control cycle;
- voltage and/or current control; or
- a minimum five-position switch (four settings and “off”).

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<sup>20</sup> Under certain conditions, additional free available chlorine or bromine may be required by the regulatory agency having authority. These are minimum requirements and the local and/or state regulations shall take precedent where it is higher.

## 16.6 Life test

The system shall be capable of operating 3000 continuous hours at 80% of the output rate recommended by the manufacturer. Tests shall be conducted on three units. At least one unit shall complete 3000 h, and a minimum 8000 satisfactory operating hours shall be accumulated among the three units. The manufacturer's recommended routine maintenance may be performed on the system during the test.

## 16.7 Uniformity of output

At any setting, the system shall deliver the active ions into the water at a rate within  $\pm 20\%$  of that shown by the feed rate indicator. At any setting between 25% and 100%, the feeder output shall be reproducible within  $\pm 10\%$  or  $\pm 0.1$  mg/L, whichever is greater.

## 16.8 Test kit

The test kit supplied with the system by the manufacturer to measure the copper concentrations in the water shall provide accurate and reliable measurements. A test method shall be available through the manufacturer to measure the silver concentrations in the water.

### 16.8.1 Test kit accuracy

Copper test kits shall conform to the following accuracy requirements:

- $\pm 0.1$  ppm at the recommended use concentration range;
- $\pm 20\%$  at the maximum limit of 1.3 ppm; and
- $\pm 10\%$  repeatability for three replicate samples.

## 16.9 Operation and installation instructions

In addition to the requirements provided in 11.6 of this Standard, caution statements shall be prominently displayed in the operation and installation instructions advising the user of the following:

- materials not compatible with the system;
- the potential of staining of pool materials if the system is not operated properly;
- the importance of maintaining a minimum residual of the free available chlorine or bromine;
- a description of the test method available through the manufacturer to measure the silver concentrations in the water;
- the recommended pH range;
- the electrode part number; and
- caution statements that include the possibility of staining and the measures needed to avoid its occurrence.

### 16.10 Data plates(s)

Data plate(s) shall be permanent; easy to read; and securely attached, cast, or stamped onto the unit at a location readily accessible after normal installation. Data plate(s) shall contain at least the following:

- equipment name;
- manufacturer's name;
- model number;
- electrical requirements – volts, amps, and Hertz (if applicable);
- serial number and/or date of manufacture;
- caution statements referring user to operation manual for applicable warnings (prominently displayed) including a caution statement that the unit is designed for supplemental disinfection and should be used with registered or approved disinfection chemicals to impart required residual concentrations; and
- capacity (pool volume) or output rate (in cu/time at each setting).

### 16.11 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 Automated Controllers

### 17.1 Scope

Automated controllers are used to monitor water conditions such as pH, ORP, free chlorine and/or other parameters specified by the manufacturer and to control equipment such as chemical feeders and pumps. Equipment covered by this section includes the controller and the chemical probes, and/or flow cells. Water contact components and materials of automated controllers shall be evaluated to the health effects criteria of Section 3. Mechanical Chemical Feeders are covered in Section 9, and Flow-through Chemical Feeders are covered in Section 10.

### 17.2 Chemical resistant materials

Parts normally in contact with the chemically treated water shall be resistant to the solutions specified in M.1.2.

### 17.3 Monitor display

The automated controller shall be equipped with a display that indicates:

- operation status (if the parameter is above or below set point);
- whether the automated controller is working properly as specified in 17.6.

- if an automated controller has a digital or analog display, then applicable parameter levels (pH, ORP, etc.) shall be displayed using the following units of measurement, as applicable:

ORP	millivolts (mV)
pH	pH units
temperature	degrees Fahrenheit (°F) or degrees Celsius (°C)
turbidity	Nephelometric Turbidity Units (NTU)
free available chlorine or bromine	parts per million (ppm) or mg/L
total chlorine or bromine	parts per million (ppm) or mg/L

#### 17.4 Life test

Three automated controllers shall be evaluated per M.2.4. A minimum of one of three controllers shall complete 110,000 actuation cycles, and a minimum of 295,000 cycles shall be accumulated between the three controllers. None of the controllers shall fail at or below 80,000 cycles. Each cycle shall consist of operating the controller for 1 sec on, 9 sec off, at the manufacturer's maximum rated load. The life test is independent of other tests. The display tests shall be performed after the chemical resistance tests.

#### 17.5 Performance

##### 17.5.1 Operating conditions

The automated controller shall respond with output signals that accurately correspond with the varying input signal when tested per Annex M at four increments between 0% and 100% of the operating ranges specified in Table 17.1. The automated controller may be tested at four increments between 0% and 100% of the manufacturer's full operating range if it is more restrictive than a range listed in Table 17.1. The automated controller shall meet the requirements of this section before and after the chemical resistance test.

**Table 17.1 – Operation range for automated controllers (as applicable)**

Parameter	Suggested Operation Ranges	Measurement Accuracy
ORP	650 mV to 850 mV	± 20 mV
pH	6.8 to 8.2	+ 0.2
free available chlorine or bromine	0 to 10 ppm as Cl <sub>2</sub> 0 to 20 ppm as Br <sub>2</sub>	10%
total chlorine or bromine	0 to 10 ppm as Cl <sub>2</sub> 0 to 20 ppm as Br <sub>2</sub>	10%

For other parameters, testing shall be conducted at four increments between 0 and 100% of the full operating range.

If an automated controller does not have a digital or analog display, then an alternate means of verification shall be conducted. This alternate shall be outlined by the manufacturer and must be able to demonstrate control of the pH and chlorine values of the water as specified in Table 17.1.

##### 17.5.2 Set point

At any set point within a parameter range specified in Table 17.1, an automated controller shall provide an equipment actuation signal (actuate) in response to the signal from an applicable sensor. The actual parameter value at which the automated controller actuates shall be within the tolerance specified in Table 17.1 relative to the set point.

## 17.6 Failure sensing and signaling devices

The automated controller shall possess a default mechanism or process capable of detecting and delivering a distinct visible signal to notify the user when the controller is not maintaining a parameter within the acceptable range for swimming pool or spa/hot tub water as set by the user.

## 17.7 Operational Protection

**17.7.1** The automated controller shall have an automatic mechanism for preventing the operation of any chemical feeder actuated by the controller whenever water circulation at the chemical injection points is interrupted, or the manufacturer shall provide printed materials warning the user of the potential for elevated chemical concentrations and/or hazardous gas introduction into the pool or spa resulting from conditions of no flow in the recirculation system.

**17.7.2** The controller shall automatically turn off the equipment actuated by the controller when:

- a parameter maintained by the automated controller remains outside the set point range for longer than the manufacturer's recommended time limit;
- an equipment operation cycle (e.g. chemical feed cycle) exceeds the manufacturer's recommended time limit.

## 17.8 Operation and installation instructions

The manufacturer shall supply installation and operation instructions with each automated controller. These instructions shall include the following:

- proper installation, operation, and maintenance instructions;
- diagrams and a parts list to facilitate the identification and ordering of replacement parts;
- replacement probe or sensor model numbers and sensor output signal requirements;
- maximum external load rated in volts and amps; and
- caution statement warning the user that the automatic controller should not be installed where it is accessible to the public.
- Applicable operating ranges (such as pH and ORP minimum and maximum) for the automated controller.

## 17.9 Data plates

Data plates shall be permanent, easy to read, and securely attached, cast, or stamped onto the automated controller at a location readily accessible after normal installation. Data plates shall contain at least the following:

- equipment name;
- manufacturer's name and address;
- model number;
- electrical requirements; volts, amps, and Hertz;

- maximum external load rated in volts and amps;
- serial number and date of manufacture;
- caution statements (prominently displayed);
- replacement sensor model numbers or sensor output signal requirements, or both.

## **18 Water Quality Testing Devices**

### **18.1 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.

### **18.2 Testing**

WQTD units selected for testing shall be from at least 2 different batches or manufacturing runs. Products are conditioned and/or calibrated 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.

#### **18.2.1 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.

#### **18.2.2 Temperature of solution used for testing**

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

#### **18.2.3 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.

#### **18.2.4 Chlorine (free and combined) testing**

A WQTD that tests free and combined chlorine shall meet the requirements of annex N. The WQTD shall be used to analyze test solutions within each range shown in N.6.2 if the range includes a concentration within the operating range of the WQTD. 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. The data shall be compared between units to determine reproducibility.

### 18.2.5 Bromine testing

A WQTD that tests bromine shall meet the requirements of annex N. The WQTD shall be used to analyze test solutions within each range shown in N.6.3 if the range includes a concentration 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.

### 18.2.6 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.

### 18.2.7 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.

### 18.2.8 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. For test strip/comparators the result shall be within the limits stated in Annex N.

## 18.3 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.

## 18.4 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 or part number of the unit;
- Parts list to facilitate the identification and ordering of replacement parts (or referral to a manual or website for those units with size constraints);
- WQTD classification level (L1, L2, L3) for each parameter (or lowest level achieved); and
- Disposal date of the WQTD and its components.

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## **Annex A<sup>21</sup>** (informational)

### **Materials review and qualification methods**

#### **A.1 Purpose**

The purpose of these methods is to document that the materials used in contact with pool or spa/hot tub (product) water do not impart undesirable levels of contaminants or color to the product water.

It is recognized that the product water is not intended for human consumption; that it is not feasible or cost-effective to identify every contaminant that might be contributed to the product water; and that there may not be complete toxicological information available on each contaminant identified. Therefore, these methods are designed to:

- determine from the material formulation those contaminants of toxicological concern likely to be contributed to the product water;
- determine the general level of contaminants contributed to the product water by the material, using screening tests; and
- determine the levels of specific contaminants, particularly regulated metals and organics, contributed to the product water by the material.

#### **A.2 Formulation review**

Where required for conformance to 3.2 of this Standard, complete material formulation information shall be reviewed to determine whether a material is suitable for contact with the product water, to assess the potential for contaminants to be contributed to the product water from the material, to determine whether extraction testing is warranted, and to select the appropriate extraction testing parameters.

#### **A.3 Exposure testing**

##### **A.3.1 General description**

When extraction testing is warranted based on a material formulation, a multiple exposure procedure shall be followed. Under this procedure, material samples shall be submerged for specific durations in water having defined characteristics (exposure water). Upon completion of the exposures, the water (extraction water) shall be analyzed for the selected contaminants of concern. The contaminant concentrations observed shall be normalized to represent exposure conditions in the field. The normalized concentration (estimated exposure level or remove this statement) shall be compared to an established maximum contaminant level or a level of toxicological concern for drinking water. Chemical feeders and generators may be tested according to the requirements of NSF/ANSI 61 utilizing tap water and the manufacturer's recommended chemicals, or specific components requiring testing may be evaluated to this Annex.

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<sup>21</sup> The information contained in this Annex is not part of this American National Standard (ANS) and has not been processed in accordance with ANSI's requirements for an ANS. Therefore, this Annex may contain material that has not been subjected to public review or a consensus process. In addition, it does not contain requirements necessary for conformance to the Standard.

### A.3.2 Selection of parameters for exposure testing

The selection of potential contaminants for which testing is warranted shall be based on the review of the material formulation, the toxicological significance of the ingredients, and the likelihood of their migration. Analysis for phenolic substances and total organic carbon (TOC) may be used as screening tests to determine whether additional testing is warranted for specific potential contaminants. Exposure testing may also be conducted to determine whether a material may impart color to water.

### A.3.3 Exposure water

The condition of exposure water shall be based on the nature of the contaminant of concern. Exposure water having the following characteristics shall be prepared (note that parameters, especially temperature, may change during the exposure period):

	Extraction of metals/inorganics	Extraction of organics
pH range	7.2-7.4	7.2-7.4
chlorine	2.0 mg/L $\pm$ 0.2 mg/L	0.0 mg/L
hardness (as CaCO <sub>3</sub> )	150 mg/L $\pm$ 10 mg/L	150 mg/L $\pm$ 10 mg/L
Temperature	38 $\pm$ 5 °C (100 $\pm$ 10 °F)	38 $\pm$ 5 °C (100 $\pm$ 10 °F)

### A.3.4 Exposure conditions

Samples shall be exposed to exposure water in three successive intervals according to the following schedule:

1	24 $\pm$ 1 h
2	24 $\pm$ 1 h
3	72 $\pm$ 4 h

After each of the first two exposure periods, the extraction water shall be discarded and the sample exposed to fresh exposure water. The extraction water from the third exposure interval shall be analyzed for the selected contaminants. All exposures shall be conducted at an ambient air temperature of 23  $\pm$  2 °C (73  $\pm$  3 °F).

### A.3.5 Ratio of sample surface area to exposure water volume

When material or component samples are evaluated the ratio of the sample surface area to the volume of exposure water shall be 6500 cm<sup>2</sup> (1000 in<sup>2</sup>) to 4 L (1 gal).

Filtration, and adsorption medias shall be exposed at the manufacturer's recommended use ratio of weight of media per unit void volume.

Precoat media shall be exposed at 10 times the manufacturer's recommended use ratio.

### A.3.6 Analytical methods

Analyses of extraction water shall be conducted in accordance with the procedures in the following:

- *Standard Methods for the Examination of Water and Wastewater*;
- *Methods for Chemical Analysis of Water and Wastes*;
- *Methods for the Determination of Organic Compounds in Drinking Water, Supplement 1*; or
- *Methods for the Determination of Inorganic Substances in Environmental Samples*.

### A.3.7 Normalization

The normalized extraction level for a contaminant shall be calculated by  $C_F = C_L (SA_F/V_F) (V_L/SA_L)$ ; where:

- $C_F$  = Contaminant concentration in field
- $C_L$  = Contaminant concentration in lab
- $SA_F$  = Surface area of material in the field
- $SA_L$  = Surface area of material in the lab
- $V_F$  = Volume of water in the field
- $V_L$  = Volume of water in the lab

If the surface area to volume ratio in the field is not known the normalized extraction level is calculated by dividing the concentration in the extraction water by a factor of 10. This is based on the assumption that the worst case surface area to volume ratio of the material is 25 square inches per liter. All medias shall be normalized to the manufacturer's recommended use ratio.

### A.3.8 Acceptance criteria

The normalized extraction concentration of a potential contaminant shall not exceed the Total Acceptable Concentration (TAC) established by NSF/ANSI 61.

The color rating of the extraction water, as determined in accordance with APHA Standard Method 2120B (*Standard Methods for the Examination of Water and Wastewater*), shall not exceed that of the exposure water (control).

Certification listings and manufacturer's literature for swimming pool materials (excluding components and devices) shall contain surface area to volume restrictions associated with the evaluation.

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**Annex B**  
(normative)

**Test methods for the evaluation of filters**

NOTE – The test conditions specified in this annex are not intended to represent recommended field use conditions.

**B.1 Hydrostatic pressure test (pressure service filters)**

**B.1.1 Purpose**

The purpose of this test is to verify the hydrostatic integrity of a pressure service filter tank.

**B.1.2 Apparatus**

- a pressure testing rig capable of delivering and regulating hydrostatic pressure on a filter tank;
- temperature-indicating device (required accuracy:  $\pm 1\text{ }^{\circ}\text{C}$  [ $\pm 2\text{ }^{\circ}\text{F}$ ]);
- timer (required accuracy:  $\pm 0.5\text{ s}$ ); and
- pressure gauges sized to yield the measurement within 25% to 75% of full scale (required accuracy:  $\pm 2\%$  of reading or  $\pm 1\text{ psi}$ , whichever is greater).

NOTE – Electronic transducers may be used for recording test data. Transducers shall meet the accuracy requirements for gauges, but the measurement does not need to be within 25% to 75% of the range of the transducer.

**B.1.3 Challenge water**

	swimming pool/spa/hot tub filters
water temperature	$24 \pm 6\text{ }^{\circ}\text{C}$ ( $75 \pm 10\text{ }^{\circ}\text{F}$ )

**B.1.4 Hydrostatic pressure test method (pressure service filters)**

- a) Install filter media and/or elements and all integral components according to the manufacturer's instructions. Connect the filter to the pressure-testing rig.
- b) Fill the unit with the appropriate challenge water and bleed off all air.
- c) Adjust the pressure regulator to apply a hydrostatic pressure equal to 1.5 times the working pressure of the unit. Maintain the pressure for  $300 \pm 30\text{ s}$ . Slowly release the pressure and examine the tank and its integral components for evidence of a rupture, leak, burst, or other deformation.
- d) Adjust the pressure regulator to apply a hydrostatic pressure of  $207 \pm 7\text{ kPa}$  ( $30 \pm 1\text{ psi}$ ) and maintain it for  $2 \pm 0.5\text{ s}$ . The pressurization rate shall not exceed  $30\text{ psi/s}$ . Slowly release the pressure and maintain a hydrostatic pressure of  $0\text{ kPa}$  ( $0\text{ psi}$ ) for  $2 \pm 0.5\text{ s}$ . Automatic timers shall be used to ensure that the proper pressures are applied and maintained for the required intervals.

Repeat this cycle 20,000 times and examine the tank and its integral components for evidence of a rupture, leak, burst, or other deformation.

e) After the cycle test in step d), adjust the pressure regulator so that the pressure applied on the filter increases steadily and reaches a hydrostatic pressure equal to twice the working pressure within 60 to 70 s. Slowly release the pressure, drain the filter, and examine the tank for evidence of a rupture, leak, burst, or other deformation.

**B.1.5 Acceptance criteria**

There shall be no rupture, leakage, burst, or permanent deformation of the filter tank or its integral components during the three phases of the test, except that leakage from integral components such as valves and fittings during the third phase of the test (as described in annex B, B.1.4, step e)) shall not constitute a failure.

**B.2 Vacuum test (vacuum service filters)**

**B.2.1 Purpose**

The purpose of this test is to verify the integrity of vacuum service filter tanks whose inlets may be closed during part of the operating cycle.

**B.2.2 Apparatus**

- vacuum source capable of creating a vacuum on a filter tank as required by this test;
- temperature-indicating device (required accuracy is  $\pm 1^\circ\text{C}$  [ $\pm 2^\circ\text{F}$ ]);
- timer (required accuracy is  $\pm 0.5$  s); and
- vacuum gauges sized to yield the measurement within 25% to 75% of full scale (required accuracy is  $\pm 2\%$  of reading or  $\pm 1$  psi, whichever is greater).

NOTE – Electronic transducers may be used for recording test data. Transducers shall meet the accuracy requirements for gauges, but the measurement does not need to be within 25% to 75% of the range of the transducer.

**B.2.3 Challenge water**

	swimming pool/spa/hot tub filters
water temperature	$24 \pm 6^\circ\text{C}$ ( $75 \pm 10^\circ\text{F}$ )

**B.2.4 Vacuum test method (vacuum service filters)**

a) Install filter media and/or elements and all integral components according to the manufacturer’s instructions. Connect the filter to the vacuum source.

b) Adjust the pressure regulator to apply a vacuum of  $85 \pm 3.4$  kPa ( $25 \pm 1$  in Hg) to the filter tank. Maintain the vacuum for  $300 \pm 30$  s. Slowly release the vacuum and examine the tank for evidence of a rupture, collapse, leak, or other deformation.

**B.2.5 Acceptance criteria**

There shall be no rupture, collapse, leak, or other deformation of the filter tank.

**B.3 Head loss test**

**B.3.1 Purpose**

The purpose of this test is to verify that the initial head loss from the filter inlet to the filter outlet does not exceed the maximum head loss as specified by the manufacturer, and to verify that the initial head loss for an alternate sand-type media does not exceed the initial head loss of sand.

**B.3.2 Apparatus**

- pressure-recording device (required accuracy is  $\pm 0.5$  of the smallest division used in the manufacturer’s claimed pressure loss);
- turbidimeter (required accuracy from 0 to 10 NTU is  $\pm 0.5$  NTU; required accuracy above 10 NTU is  $\pm 5\%$  of the reading or  $\pm 1$  NTU, whichever is greater);
- temperature-indicating device (required accuracy is  $\pm 1$  °C [ $\pm 2$  °F]);
- flow meter (required accuracy is  $\pm 4$  Lpm ( $\pm 1$  gpm) or  $\pm 2\%$  of reading, whichever is greater);
- water tank and pump system capable of delivering water at the design flow rate and proper temperature through the filter; and
- pressure measurement taps sized to the filter’s inlet and outlet.
- For testing the initial head loss of an alternate sand-type media, the media shall be installed in a 24-in diameter sand-type filter for which the head loss with sand is known.

**B.3.3 Challenge water**

	swimming pool/spa/hot tub filters
water temperature	$24 \pm 6$ °C ( $75 \pm 10$ °F)
turbidity	$\leq 2$ NTU

**B.3.4 Method**

- a) Install a pressure measurement tap at the filter inlet and the filter outlet. The taps should be connected by a hose to the pump outlet and return. Determine the head loss due to any restriction between the filter inlet or outlet and the installed pressure measurement taps. This head loss should be subtracted from the head loss measured during operation.
- b) Condition filter per the manufacturer's instructions and initiate a filter cycle at the design flow rate.
- c) Operate the unit at the design flow rate for  $300 \pm 30$  s. See special instructions in annex B, section B.3.4, f) for testing sand filters.

- d) Measure and record the inlet and outlet static pressures.
- e) Calculate the head loss using one of the following equations:

$$\text{HLF} = (P_1 - P_2) + [Z_1 \times (9.81) W]/1000 - \text{HLP}$$

where:

HLF = head loss due to filter (kPa);  
 $P_1$  = inlet static pressure (kPa);  
 $P_2$  = outlet static pressure (kPa);  
 $W$  = density of water ( $\text{kg}/\text{m}^3$ );  
 $Z_1$  = height of inlet centerline above outlet centerline (m); and  
 HLP = head loss due to piping from  $P_1$  to  $P_2$  (kPa).

or

$$\text{HLF} = [(144 \times (P_1 - P_2))/W] + Z_1 - \text{HLP}$$

where:

HLF = head loss due to filter (ft);  
 $P_1$  = inlet static pressure (psig);  
 $P_2$  = outlet static pressure (psig);  
 $W$  = specific weight of water ( $\text{lb}/\text{ft}^3$ );  
 $Z_1$  = height of inlet centerline above outlet centerline (ft); and  
 HLP = head loss due to piping from  $P_1$  to  $P_2$  (ft).

NOTE – conversions:

$$\text{HLF (m)} \times 9.81 = \text{HLF (kPa)}$$

$$\text{HLF (ft)} \times 0.4335 = \text{HLF (psi)}$$

$$P \text{ (psi)} \times 2.307 = P \text{ (ft)}$$

This analysis assumes that the inlet and outlet piping are of the same size, material, and general condition. If this is not the case, these factors shall be taken into account.

- f) When testing sand filters, operate the filter at the design flow rate for an additional 6 h. Slowly reduce the flow to zero, shut down the system, and slowly drain the filter. Sudden reductions in flow can invalidate this test, as the water surge (including reversal of flow) can re-settle the sand bed. Examine the surface of the filter media bed for conformance to 5.3.5.3 of this Standard.

### B.3.5 Acceptance criteria

The measured head loss shall not exceed the design head loss specified by the filter manufacturer.

## B.4 Filter media cleanability test

### B.4.1 Purpose

The purpose of this test is to verify the effectiveness of the manufacturer's recommended procedures for the cleaning of filter media, and to verify that the cleanability of an alternate sand-type media is at least equivalent to that of sand.

**B.4.2 Apparatus**

- pressure-recording device (required accuracy is ± 0.5 of the smallest division used in the manufacturer’s claimed pressure loss);
- turbidimeter (required accuracy from 0 to 10 NTU is ± 0.5 NTU; required accuracy above 10 NTU is ± 5% of the reading or ± 1 NTU, whichever is greater);
- temperature-indicating device (required accuracy is ± 1 °C [± 2 °F]);
- flow meter (required accuracy is ± 4 (± 1 gpm) or ± 2% of reading, whichever is greater);
- water tank and pump system capable of delivering water at the design flow rate and proper temperature through the filter; and
- pressure measurement taps sized to the filter’s inlet and outlet.

For testing of the cleanability of an alternate sand-type media, the media shall be installed in a 24-in diameter sand-type filter that has previously passed the cleanability test with sand.

**B.4.3 Challenge slurries**

	swimming pool/spa/hot tub filters
water temperature	24 ± 6 °C (75 ± 10 °F)

**B.4.3.1 Swimming pool/spa/hot tub filter applications**

Tap water with 4.8 ± 1 g (0.04 ± 0.01 lb) of ball clay<sup>22</sup>, 189 mg baby oil<sup>23</sup>, and 4.8 ± 1 g (0.04 ± 0.01 lb) of diatomaceous earth (for non DE filters) added for every gallon per minute of flow rate at which the filter is tested. No diatomaceous earth is added to the challenge slurry when testing a diatomite-type filter.

**B.4.4 Method**

- a) Install and condition the filter in accordance with the manufacturer's instructions.
- b) Operate the filter at the design flow rate.
- c) Challenge the unit with the appropriate challenge slurry. Continue to operate diatomite-type and cartridge-type filters at the design flow rate until the pressure differential across the filter is equal to the manufacturer's recommended pressure differential for cleaning. Continue to operate sand filters until the pressure differential across the filter is equal to the manufacturer's recommended pressure differential for cleaning or 103 kPa (15 psi), whichever is greater.

NOTE – Upon reaching the desired pressure differential during the testing of sand filters, slowly reduce the flow to zero, shut down the system, and slowly drain the filter. Sudden reductions in flow can invalidate this test, as the water surge (including reversal of flow) can re-settle the sand bed. Examine the surface of the filter media bed for conformance to 5.3 of this Standard.

<sup>22</sup> A possible resource for ball clay: OM-4 (old Mine 4), Rovin Ceramics, Taylor, MI 48180

<sup>23</sup> A possible resource for baby oil: Johnson’s Baby Oil®, One Johnson & Johnson Plaza, New Brunswick, New Jersey 08933

- d) Clean the unit per the manufacturer's instructions. Examine the filter media, elements, or cartridges for soil, organics, and filter aid.
- e) Operate the unit in accordance with the test method in annex B, section B.3.4 and determine the head loss at the design flow rate.

#### **B.4.5 Acceptance criteria**

The filter media or elements shall be visibly free of soil, organics, and filter aid. The head loss through the filter after cleaning the media shall not exceed 150% of the initial head loss through the filter as determined in accordance with annex B, section B.3. The head loss through the filter after cleaning shall not exceed the maximum design head loss.

### **B.5 Turbidity reduction test**

#### **B.5.1 Purpose**

The purpose of this test is to verify that a filter is capable of effectively reducing water turbidity caused by suspended particulate matter, and to verify the turbidity reduction capability of an alternate sand-type media.

#### **B.5.2 Apparatus**

- flow meter (required accuracy is  $\pm 4$  Lpm ( $\pm 1$  gpm) or  $\pm 2\%$  of reading, whichever is greater);
- pressure-recording device (required accuracy is  $\pm 0.5$  of the smallest division used in the manufacturer's claimed pressure loss);
- turbidimeter (required accuracy from 0 to 10 NTU is  $\pm 0.5$  NTU; required accuracy above 10 NTU is  $\pm 5\%$  of the reading or  $\pm 1$  NTU, whichever is greater);
- temperature-indicating device (required accuracy is  $\pm 1$  °C [ $\pm 2$  °F]);
- silica #140<sup>24</sup>;
- water tank and pump system capable of delivering water at the design flow rate through the filter; and
- pressure measurement taps sized to the filter's inlet and outlet.
- For testing the turbidity reduction of an alternate sand-type media, the media shall be installed in a 24-in diameter filter with a maximum bed depth of 10 in. A tank with 630 gal of challenge water shall be prepared for the test. A manufacturer may have media tested in a larger filter with a correspondingly larger volume of challenge water. If the media is tested in a filter larger than 24 in, the media approval shall be limited to the test filter size or larger.

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<sup>24</sup> A possible resource for U. S. Silica Model Sil-co-Sil 106, U. S. Silica Co., P. O. Box 187, Berkeley Springs, WV 25411

**B.5.3 Challenge water**

	swimming pool/spa/hot tub filters
water temperature	24 ± 6 °C (75 ± 10 °F)
turbidity prior to adding silica	≤ 2 NTU
turbidity after adding silica #140	45 ± 10 NTU

**B.5.4 Turbidity reduction test method**

- a) Determine the volume of water needed to achieve a turnover rate of no greater than 30 min when the filter is operated at the design flow rate. Fill the test tank with the required volume of water.
- b) Sample the water in the tank and determine the turbidity level (TB1) in NTU. Add a sufficient quantity of silica #140 to obtain a turbidity level (TB2) of 45 ± 10 NTU.
- c) Install and condition the filter according to the manufacturer's instructions. Operate the filter at the design flow rate.
- d) After operating the filter for the time required to filter one tank volume, draw a sample from the filter effluent and measure the turbidity (TB3). Repeat for the next four tank volumes.
- e) Calculate the turbidity remaining (TR) ratio at each tank volume using the following equation:

$$TR = (TB3 - TB1)/(TB2 - TB1)$$

**B.5.5 Acceptance criteria**

After the fifth tank volume, the TR ratio shall be ≤ 0.3. This is equivalent to a 70% or greater reduction in turbidity.

**B.6 Precoat media-type filters – turbidity limits, precoat operation****B.6.1 Purpose**

The purpose of this test is to verify that a precoat media-type filter does not pass an excess of filter aid in the effluent generated during the first 1 min of the precoating operation. This test does not apply to precoat media-type filters designed to refilter or dispose of effluent generated during the precoating operation.

**B.6.2 Apparatus**

- flow meter (required accuracy is ± 4 Lpm (± 1 gpm) or ± 2% of reading, whichever is greater);
- pressure-recording device (required accuracy is ± 0.5 of the smallest division used in the manufacturer's claimed pressure loss);
- turbidimeter (required accuracy from 0 to 10 NTU is ± 0.5 NTU; required accuracy above 10 NTU is ± 5% of the reading or ± 1 NTU, whichever is greater);
- temperature-indicating device (required accuracy is ± 1°C [± 2°F]);

- water tank and pump system capable of delivering water at the design flow rate and proper temperature through the filter; and
- pressure measurement taps sized to the filter’s inlet and outlet.

### B.6.3 Challenge water

	swimming pool/spa/hot tub filters
water temperature	24 ± 6 °C (75 ± 10 °F)
turbidity	≤ 2 NTU

### B.6.4 Precoat media-type filters – turbidity limits, precoat operation test method

- a) Install and condition the filter in accordance with the manufacturer's instructions. Establish a filtration rate of 84 Lpm/m<sup>2</sup> (2 gpm/ft<sup>2</sup>).
- b) Prepare a filter aid slurry as prescribed in the manufacturer's instructions. Pour the slurry into the feed system reservoir.
- c) Draw a sample from the filter influent line and determine the initial turbidity of the influent water.
- d) Open the slurry feed valve so as to introduce the filter aid slurry in a period of 10 s or less. Close the feed valve so as not to introduce air into the suction line after the slurry has vacated the reservoir.
- e) Draw a sample from the filter effluent line at 15-s intervals for the first 1 min after closing the slurry feed valves for a total of four samples. Measure the turbidity of each sample.
- f) Calculate the average turbidity of the four effluent samples. Calculate the average turbidity contributed by the filter by subtracting the initial influent turbidity from the average turbidity of the four effluent samples.

### B.6.5 Acceptance criteria

The average turbidity contributed by the filter during the first 1 min of the precoat process shall not exceed 10 NTU.

## B.7 Cellulose media longevity test

### B.7.1 Purpose

The purpose of this test is to verify that the cellulose media performs comparably to the DE for the life of one charge.

### B.7.2 Apparatus and test method

- a) Set up a tank and pump assembly with a capacity of at least 662 L (175 gal) and pump it to a precoat filter conforming to this Standard that has a filtration area between 1.9 and 3.7 m<sup>2</sup> (20 and 40 ft<sup>2</sup>).

- b) Place a flow meter in the loop and two pressure gages; one on the inlet and one on the outlet of the filter.
- c) Condition the tank's water per annex B, table B.1.
- d) Charge the filter with the DE grade specified by the manufacturer.
- e) Set the flow rate to 81 L/min/m<sup>2</sup> (2 gal/min/ft<sup>2</sup>) of filter area.
- f) When the water clears, record the pressure drop.
- g) Run the test continuously while administering the doses in annex B, section B.7.3 until the pressure drop increases by 70 kPa (10 psi) or the flow rate drops by 40 Lpm (10 gpm).
- h) Duplicate the test setup with the cellulose media.

**Table B.1 – Challenge water**

pH	turbidity	free chlorine
7.5± 0.5	< 1	1-2 ppm

**B.7.3 Dosing**

- a) Prepare a ball clay mixture by mixing 1270 gm (2.80 lb) ball clay 45 gm (0.10 lb) of baby oil and 3625 gm (7.99 lb) of water.
- b) Dose a 55 gm (0.12 lb) of this mixture into each of the tanks once a day, 5 d/wk.
- c) Take a water sample just before the dosing, and record the turbidity and the free available chlorine.

**B.7.4 Acceptance criteria**

The cellulose media shall last at least as long as DE before a recharge is needed. The turbidity level measured in annex B, section B.7.3 shall not exceed 1 NTU throughout the duration of the test.

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## Annex C (normative)

### Test methods for the evaluation of centrifugal pumps

NOTE – The test conditions specified in this annex are not intended to represent recommended field use conditions.

#### C.1 Performance curve verification

##### C.1.1 Purpose

The purpose of this test is to verify the accuracy of the manufacturer's pump performance curve, as required in 6.6.

##### C.1.2 Apparatus

- pressure-indicating device (e.g., mercury manometer);
- vacuum-indicating device;
- pressure gauges meeting ANSI B40.100 Grade 3A specifications and sized to yield the measurement within 25 to 75% of scale;
- turbidimeter scaled in nephelometric turbidity units (NTU);
- variac electrical supply system; and
- flow meter.

##### C.1.3 Test conditions

	swimming pool	hot tubs / spa
water temperature	$24 \pm 6 \text{ }^\circ\text{C}$ ( $75 \pm 10 \text{ }^\circ\text{F}$ )	$39 \pm 3 \text{ }^\circ\text{C}$ ( $102 \pm 5 \text{ }^\circ\text{F}$ )
turbidity	$\leq 15 \text{ NTU}$	$\leq 15 \text{ NTU}$

NOTE – Pumps, except those labeled to be for swimming pools only, shall be tested at the hot tubs / spa temperature.

##### C.1.4 Performance curve verification method

- a) Pump shall be installed and operated according to the manufacturer's instructions. The manufacturer shall state the inlet conditions under which the published performance curves were established, and barometric pressure.
- b) Air leaks shall be avoided in the suction line. Piping shall be clean and free of scale, burrs, etc.
- c) The suction pipe end shall be submerged a distance of at least ten pipe diameters. Liquid around the suction pipe shall be relatively quiet, without entrained air, swirls, etc., from recirculated discharge.

- d) The suction and discharge gauge/manometer lines shall be purged so that the suction gauge line is free of water and the discharge gauge line is free of air.
- e) The test shall be conducted with normal rated voltage ( $\pm 10\%$ ) at motor terminals.
- f) The connection pipe shall be the same size as the pump suction and discharge tapings. A minimum of ten pipe diameters shall precede the gauges; a minimum of five pipe diameters shall follow the gauges.
- g) Discharge pressures shall be measured by a gauge or manometer to obtain results accurate to  $\pm 3$  kPa ( $\pm 0.25$  psi). The vacuum shall be measured by a manometer or gauge to obtain results accurate to  $\pm 12$  mm ( $\pm 0.5$  in) of mercury.
- h) Readings shall be taken at the center line of the pump impeller or corrected to the center line.
- i) The total dynamic head (TDH) shall be determined at ten points along the complete range of flow rates for the rated speed of the pump. The TDH shall be determined from measurements of the following:
  - lift from the centerline of the pump impeller to the discharge pressure tap;
  - flow rate;
  - vacuum (negative gauge pressure) in the suction line;
  - pressure in the discharge line; and
  - length and diameter of inlet and discharge pipes.
- j) Capacity measurement – Capacity shall be measured using a quantity meter (weight or volume) or a flow rate meter. The measurement device shall have an accuracy of  $\pm 1.5\%$  of the measured values.
- k) Power measurement – Power input shall be measured using a device having an accuracy of  $\pm 1.5\%$  of the measured values.

### **C.1.5 Acceptance criteria**

The pump performance shall meet the criteria specified in annex C, either section C.1.5.1 or section C.1.5.2.

**C.1.5.1** Over the range of flow rates up to 90% of the maximum flow, the total dynamic head at each point determined by the test shall be:

- no less than 97% of the total dynamic head indicated by the manufacturer's performance curve; and
- no more than 105% of the total dynamic head indicated by the manufacturer's performance curve.

**C.1.5.2** Over the range of total dynamic head up to 90% of the maximum flow, the flow rate at each point determined by the test shall be:

- no less than 95% of the flow rate indicated by the manufacturer's performance curve; and
- no more than 105% of the flow rate indicated by the manufacturer's performance curve.

## C.2 Hydrostatic pressure test

### C.2.1 Purpose

The purpose of this test is to verify that a pump is capable of withstanding a hydrostatic pressure equal to 150% of its working pressure.

### C.2.2 Apparatus

The test shall be performed using pressure gauges conforming to ANSI B40.100 Grade 3A specifications. The gauges shall be sized to yield the measurement within 25 to 75% of scale. Electronic pressure transducers may be used provided that the accuracy and scale are equivalent to those of a pressure gauge meeting these requirements.

### C.2.3 Test conditions

	swimming pool	hot tubs / spa
water temperature	24 ± 6 °C (75 ± 10 °F)	39 ± 3 °C (102 ± 5 °F)

NOTE – Pumps, except those labeled to be for swimming pools only, shall be tested at the hot tubs / spa temperature.

### C.2.4 Hydrostatic pressure test method

- a) If not integral with the pump, the strainer housing shall be removed. The pump shall be sealed. The pump shall be connected to a pressure source.
- b) The pump shall be filled with test water at the appropriate temperature and all air removed from the system.
- c) Increasing pressure shall be applied in a uniform manner to obtain 1.5 times the maximum shut-off head pressure in a period of 60 s to 70 s. For pumps whose power rating ≤ 75 kW (100 HP), the required pressure shall be held for 3 min ± 30 s. For pumps whose power rating > 75 kW (100 HP), the required pressure shall be held for 10 min ± 30 s.
- d) The pump housing shall be examined for leakage during the test period.

### C.2.5 Acceptance criteria

There shall be no evidence of rupture, leakage, burst, or permanent deformation of the pump housing.

## C.3 Self-priming capability

### C.3.1 Purpose

The purpose of this test is to verify the manufacturer's claim of self-priming capability.

### C.3.2 Apparatus

- suction line essentially as shown in annex C, figure C1;
- elapsed time indicator accurate to within ± 0.1 min;
- gauge pressure indicating device;

- temperature-indicating device; and
- barometric pressure indicating device.

### C.3.3 Test conditions

	swimming pool	hot tubs / spa
water temperature	24 ± 6 °C (75 ± 10 °F)	39 ± 3 °C (102 ± 5 °F)
turbidity	≤ 15 NTU	≤ 15 NTU

NOTE – Pumps, except those labeled to be for swimming pools only, shall be tested at the hot tubs / spa temperature.

### C.3.4 Self-priming capability test method

- a) The pump shall be installed and operated according to the manufacturer's instructions, except that the suction line shall be essentially as shown in annex C, figure C1.
- b) The pump shall be turned on and the timer started.
- c) The elapsed time to steady discharge gauge reading or full discharge flow shall be recorded. This is the measured priming time (MPT).
- d) The pump shall be shut off and all lines drained of water.
- e) The true priming time (TPT) shall be calculated as follows:

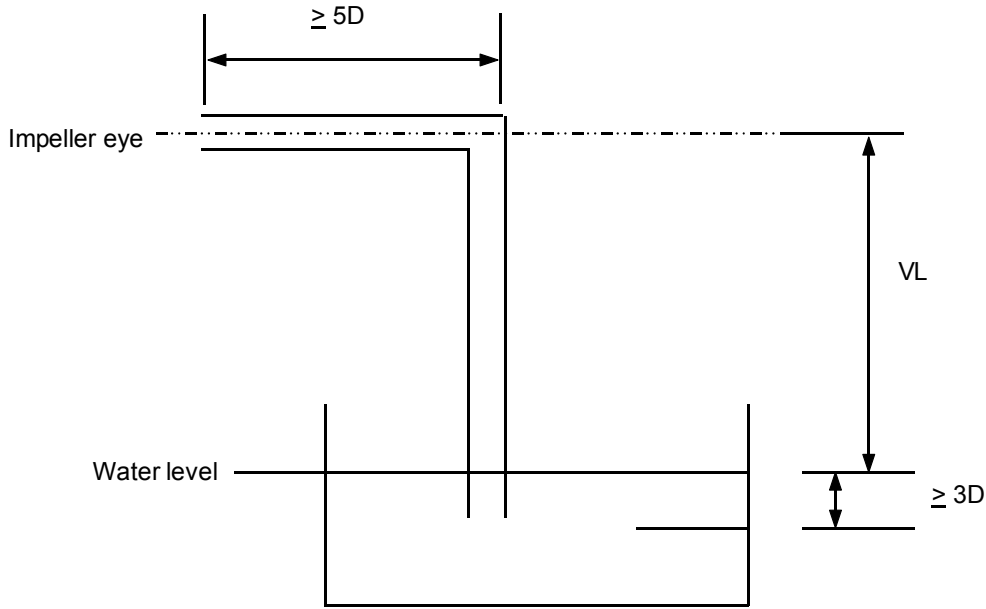
$$\text{TPT} = \text{MPT} \times (\text{pump suction inlet size} / \text{actual test pipe size})^2$$

NOTE – Typically the pump suction inlet size is equal to the test pipe size and therefore TPT = MPT.

- f) Steps b) through e) shall be repeated (no additional water shall be added to the pump).

### C.3.5 Acceptance criteria

If a pump is to be designated as self-priming, the true priming time for each run shall not exceed 6 min or the manufacturer's recommended time, whichever is greater.



**Figure C1 – Apparatus for self-priming capability test**

D = Nominal diameter of the riser pipe

VL = Vertical lift, The greater of 1.52 m (5 ft) or the manufacturer's specified lift. The vertical lift is corrected for standard temperature 20 °C [68 °F] and pressure 101 kPa [14.7 psia], with water density of 1000 kg/m<sup>3</sup> (62.4 lbs/ft<sup>3</sup>), including losses due to friction.

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## Annex D (normative)

### Test methods for the evaluation of multiport valves (MPV)

NOTE – The test conditions specified in this annex are not intended to represent recommended field use conditions.

#### D.1 Hydrostatic pressure test

##### D.1.1 Purpose

The purpose of this test is to ensure that a multiport valve and its components can withstand hydrostatic pressure 1.5 times the manufacturer's working pressure.

##### D.1.2 Apparatus/equipment

- pressure gauges meeting ANSI B40.100 Grade 3A specifications and sized to yield the measurement within 25% to 75% of scale;
- thermometer accurate to  $\pm 0.5$  °C ( $\pm 1$  °F); and
- cyclic/hydrostatic pressure testing station.

##### D.1.3 Test waters

The test waters shall meet the following requirements:

	swimming pools	hot tubs / spas
water temperature	$24 \pm 6$ °C ( $75 \pm 10$ °F)	$39 \pm 3$ °C ( $102 \pm 5$ °F)

NOTE – Multiport valves, except those labeled to be for swimming pools only, shall be tested at the spa/hot tub water temperature.

##### D.1.4 Hydrostatic pressure test method

The following procedure shall be used for the multiport valve hydrostatic pressure test:

- a) Seal the multiport valve's filter inlet and outlet ports. Connect a pressure hose from the hydrostatic testing station to the multiport valve and place the valve in the filter position.
- b) Fill the valve with water conditioned to the temperature specified in annex D, section D.1.3. Bleed off any remaining air.
- c) Uniformly increase the pressure to at least 1.5 times the working pressure and hold the pressure for no less than 5 min.
- d) Relieve the pressure and evaluate the multiport valve according to annex D, section D.1.5.
- e) Place the multiport valve in the backwash position and repeat steps in annex D, section D.1.4, steps b) through d).

**D.1.5 Acceptance criteria**

The multiport valve and its integral components shall not rupture, leak, burst, or sustain permanent deformation.

**D.2 Differential pressure/leakage test****D.2.1 Purpose**

The purpose of this test is to determine the ability of a multiport valve to seal off ports not in use during the filter and backwash cycles.

**D.2.2 Apparatus/equipment**

- pressure gauges meeting ANSI B40.100 Grade 3A specifications;
- pumping station;
- thermometer accurate to  $\pm 0.5$  °C ( $\pm 1$  °F);
- mercury manometer; and
- turbidity meter scaled in nephelometric turbidity units (NTU).

**D.2.3 Test waters**

The test waters shall meet the following requirements:

	swimming pools	hot tubs / spas
water temperature	$24 \pm 6$ °C ( $75 \pm 10$ °F)	$39 \pm 3$ °C ( $102 \pm 5$ °F)
turbidity	$\leq 15$ NTU	$\leq 15$ NTU

NOTE – Multiport valves, except those labeled to be for swimming pools only, shall be tested at the spa/hot tub water temperature.

**D.2.4 Differential pressure/leakage test method**

The following procedure shall be used for the multiport valve differential pressure/leakage test:

- a) Make the following connections (while providing an adjustable valve between them):
  - 1) Connect the multiport valve's inlet port to a pressure gauge (as specified in annex D, section D.2.2) that is also connected to the pumping station;
  - 2) Connect the return-to-pool port to the test station tank return port;
  - 3) Attach piping from the multiport valve filter inlet port to a flow control valve and pressure gauge (as specified in annex D, section D.2.2) and ultimately to the multiport valve filter output port; and
  - 4) Make any additional connections that may be necessary to conform to any unique design features specified by the manufacturer.
- b) Fill the valve with water conditioned to the applicable temperatures specified in annex D, section D.2.3, and bleed off any entrapped air.

- c) Place the multiport valve in the filter position and adjust the valves until the pressure at the multiport valve’s inlet port is at the working pressure (the pressure differential between the filter inlet port and outlet port is  $165 \pm 6.9$  kPa [ $24 \pm 1$  psi]), and the flow through the multiport valve is equal to  $\pm 0.5$  gpm ( $\pm 1.9$  Lpm) of the maximum design flow rate (see annex D, figure D1).
- d) Observe and note any change in the water level in the water tank over a minimum test period of  $5 \text{ min} \pm 30 \text{ s}$ .
- e) Connect the multiport valve’s drain port to the test tank. Relieve the pressure and place the valve in the backwash position and repeat steps in annex D, section D.2.4, steps b) through d). Calculate the rate of leakage (if any) from the return-to-pool port based on the level of rise (see annex D, figure D2).

**D.2.5 Acceptance criteria**

When tested in the filter position, the multiport valve shall show no signs of leakage from the waste port.

When the valve is tested in the backwash position, leakage from the return-to-pool port shall not exceed 0.0005 times the maximum design flow rate.

**D.3 Head loss curve test**

**D.3.1 Purpose**

The purpose of this test is to compare a head loss curve of a multiport valve to the manufacturer’s published head loss curve for both filter and backwash positions.

**D.3.2 Apparatus/equipment**

- pumping station;
- mercury manometer; and
- temperature-indicating device accurate to  $\pm 0.5$  °C ( $\pm 1$  °F).

**D.3.3 Test waters**

The test waters shall meet the following requirements:

	swimming pools	hot tubs / spas
water temperature	$24 \pm 6$ °C ( $75 \pm 10$ °F)	$39 \pm 3$ °C ( $102 \pm 5$ °F)

NOTE – All multiport valves, except those labeled to be for swimming pools only, shall be tested at the spa/hot tub water temperature.

**D.3.4 Head loss curve test method**

The following procedure shall be used for the multiport valve head loss curve test (see annex D, figure D3):

- a) Make the following connections:
  - 1) Connect the multiport valve’s inlet port to the test tank’s pump;
  - 2) Connect the multiport valve’s outlet port to the test tank return port; and

- 3) Plumb a loop connecting the filter inlet port and the filter outlet port.
- b) Start the pump and set the flow rate through the multiport valve to 25% of the maximum design flow rate ( $\pm 1.9$  Lpm [ $\pm 0.5$  gpm]).
- c) Record the following:
- static pressures, kPa (psi):
  - multiport valve inlet port (P1);
  - filter inlet port (P2);
  - filter outlet port (P3); and
  - multiport valve outlet port (P4).
  - elevations, feet (all from same reference line):
    - Z1, at elevation of P1;
    - Z2, at elevation of P2;
    - Z3, at elevation of P3; and
    - Z4, at elevation of P4.
- d) Record the static pressures at P1, P2, P3, and P4 at 50%, 75%, and 100% of the maximum design flow rate ( $\pm 0.5$  gpm [ $\pm 1.9$  Lpm]).
- e) Using the data generated according to annex D, section D.3, steps b) through d), calculate the head loss due to the multiport valve at each flow rate:
- 1) For each of the static pressures recorded in annex D, section D.3, step d), convert pressures to feet of water:
    - $P \text{ (ft)} = P \text{ (psi)} \times 2.307$
    - $P \text{ (ft)} = P \text{ (kPa)} / 2.989$
  - 2) Calculate the total head loss due to the multiport valve:
    - $HLV_{1-2} = (P1-P2) + (Z1-Z2)$
    - $HLV_{3-4} = (P3-P4) + (Z3-Z4)$
    - $HLV = HLV_{1-2} + HLV_{3-4}$
- where:
- $HLV_{1-2}$  = head loss from P1 to P2
  - $HLV_{3-4}$  = head loss from P3 to P4
  - $HLV$  = total head loss due to multiport valve
- NOTE – This analysis assumes that inlet and outlet piping are of the same size, material, and general condition. If this is not the case, these factors shall be taken into account.
- f) Move the pressure measurement device from the multiport valve outlet port to the multiport valve waste port. Place the valve in the backwash position and set the flow rate at 25% of the maximum design flow rate ( $\pm 1.9$  Lpm [ $\pm 0.5$  gpm]) (see annex D, figure D4).

g) Record the following:

- static pressures, kPa (psi):
- inlet port, P1;
- filter outlet port, P2;
- filter inlet port, P3; and
- drain port, P4 (typically ambient).

elevations, feet (all from same reference line):

- Z1, at elevation of P1;
- Z2, at elevation of P2;
- Z3, at elevation of P3; and
- Z4, at elevation of P4.

h) Record the static pressures of P1, P2, P3, and P4 at 50%, 75%, and 100% of the maximum design flow rate flow rate ( $\pm 1.9$  Lpm [ $\pm 0.5$  gpm]).

i) Using the data generated according to annex D, section D.3, steps f) through h), calculate the head loss due to the multiport valve at each flow rate according to the equations in step e).

**D.3.5 Acceptance criteria**

The measured head loss through a multiport valve shall not exceed the manufacturer’s published head loss curve by more than 10% for both the filter and backwash valve positions.

**D.4 Waste port leakage test**

**D.4.1 Purpose**

The purpose of this test is to determine whether the multiport valve waste port will leak when subjected to pressure.

**D.4.2 Apparatus/equipment**

- pressure source;
- pressure gauge meeting ANSI B40.100 Grade 3A specifications;
- sight glass assembly;
- thermometer accurate to  $\pm 0.5$  °C ( $\pm 1$  °F); and
- turbidity meter scaled in nephelometric turbidity units (NTU).

**D.4.3 Test waters**

The test waters shall meet the following requirements:

	swimming pools	hot tubs / spas
water temperature	$24 \pm 6$ °C ( $75 \pm 10$ °F)	$39 \pm 3$ °C ( $102 \pm 5$ °F)
turbidity	$\leq 15$ NTU	$\leq 15$ NTU

NOTE – All multiport valve waste ports, except those labeled to be for swimming pools only, shall be tested at the spa/hot tub water temperature.

**D.4.4 Waste port leakage test method**

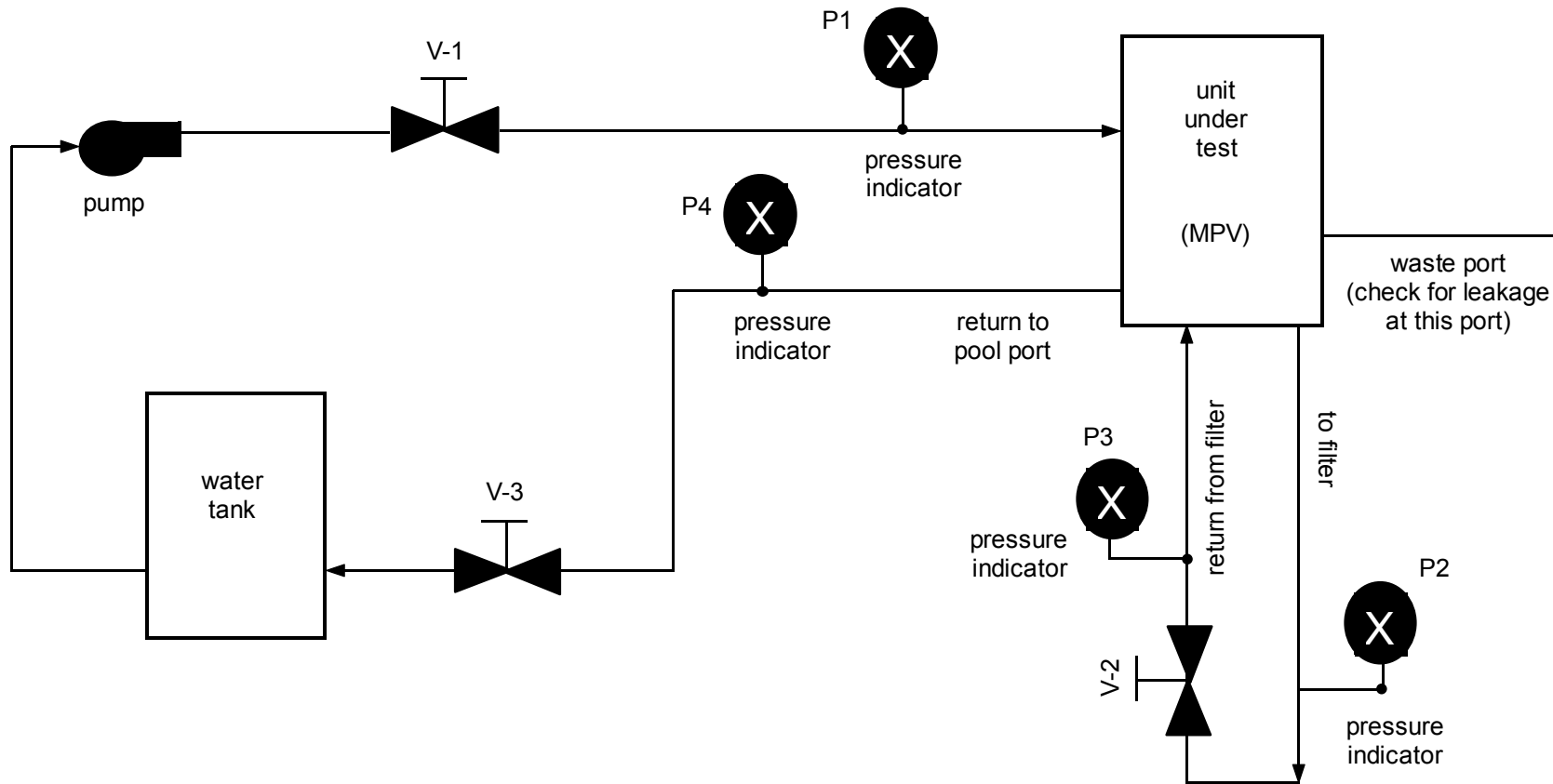
The following procedure shall be used for the multiport valve waste port leakage test:

- a) Connect the pressure source to the return-to-pool port. Place the multiport valve in the filter position.
- b) Seal the filter inlet and outlet ports and the multiport valve inlet port.
- c) Fill the multiport valve with water at the applicable temperature specified in annex D, section D.4.3, and bleed off any remaining air.
- d) Set the level in the sight glass approximately 50 mm (2 in) above the multiport valve center line and record the height.
- e) Apply a pressure of  $69 \pm 3.4$  kPa ( $10 \pm 0.5$  psi) at a rate of 13.8 kPa/min (2 psi/min) to the return-to-pool port and hold for no less than 5 min  $\pm$  30 s. Observe the valve for any leakage.

**D.4.5 Acceptance criteria**

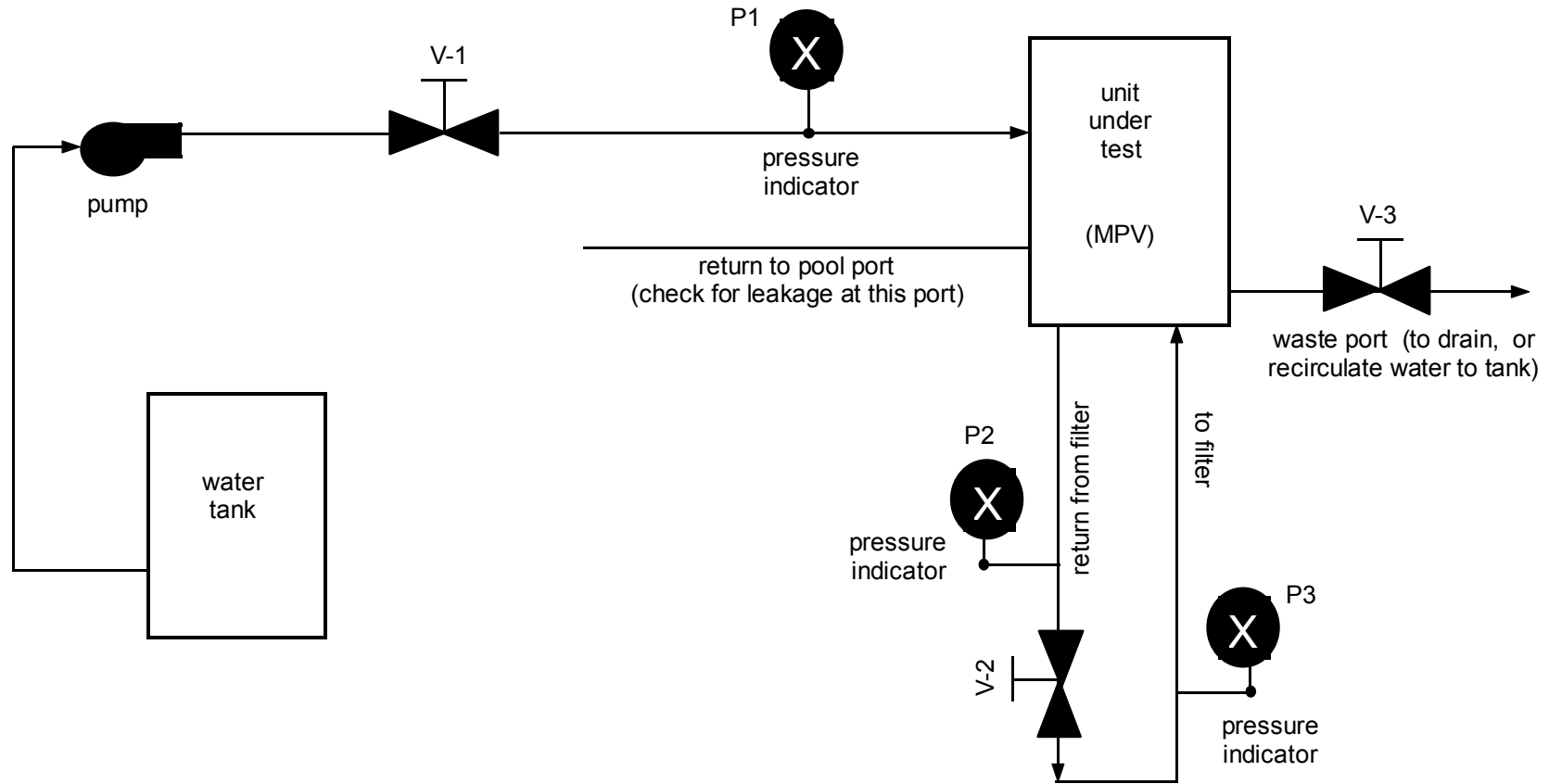
There shall be no leakage through the waste port up to 70 kPa (10 psi) or during the 5-min static test.

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NOTE — Valve V-2 is used to create the differential pressure 170 kPa (24 psi).

Figure D1 — Multiport valve differential pressure/leakage test filter position



NOTE — Valve V-2 is used to create the differential pressure 170 kPa (24 psi).

Figure D2 — Multiport valve differential pressure/leakage test backwash position

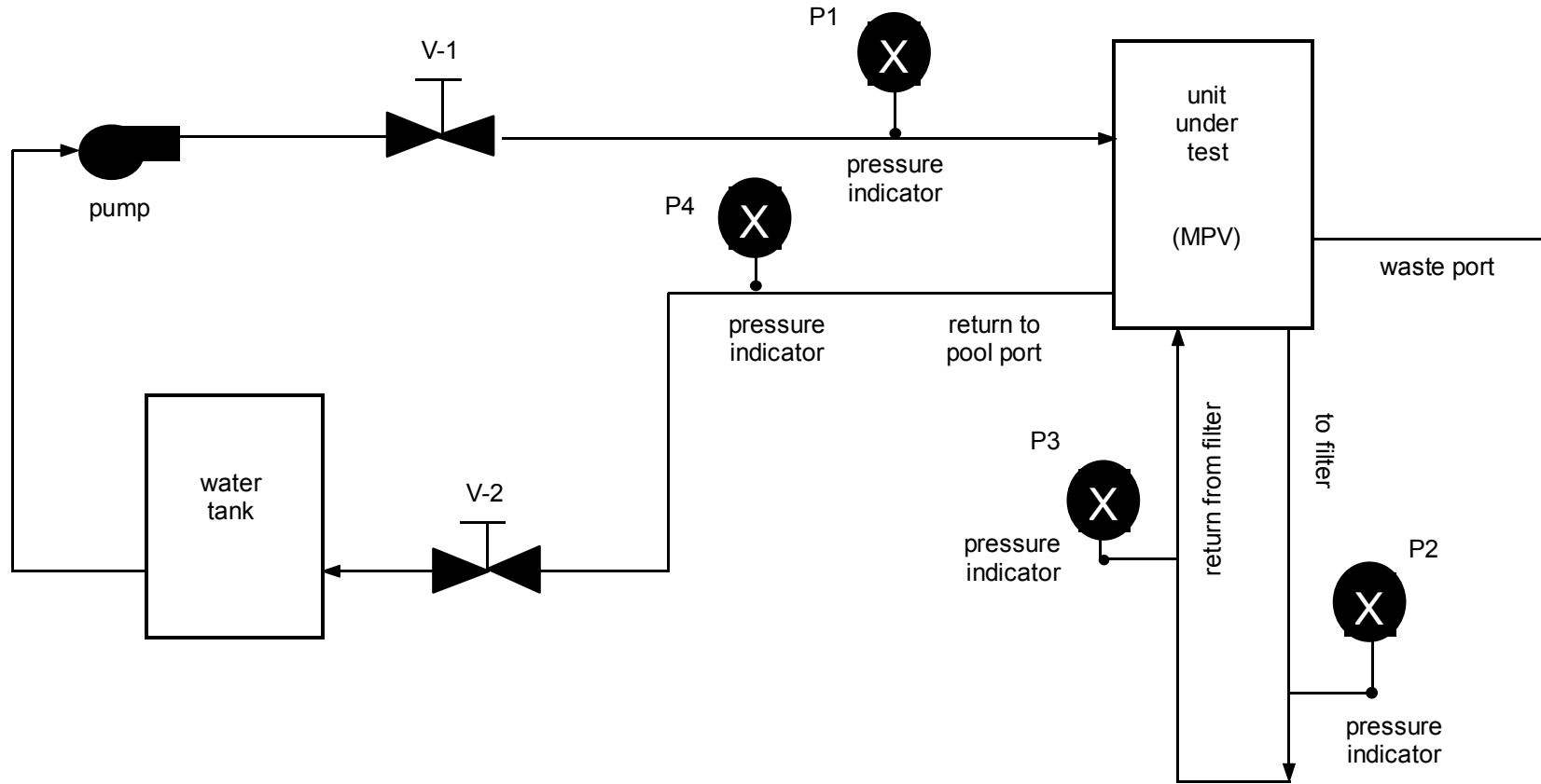


Figure D3 — Multiport valve head (pressure) loss curve test filter position

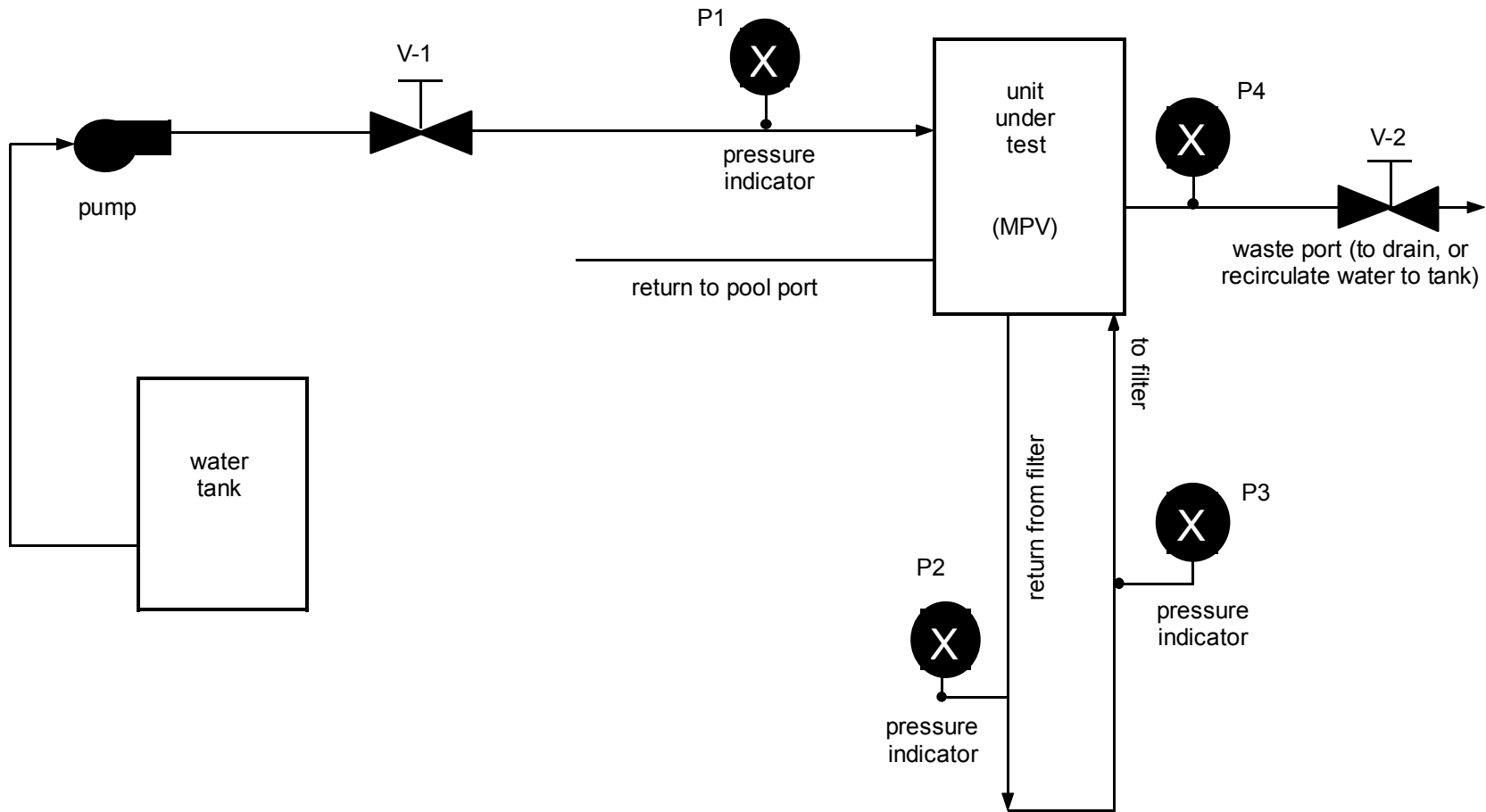


Figure D4 — Multiport valve head (pressure) loss curve test backwash position

## Annex E (normative)

### Test methods for the evaluation of recessed automatic skimmers

NOTE – The test conditions specified in this annex are not intended to represent recommended field use conditions.

## E.1 Negative pressure test

### E.1.1 Purpose

The purpose of this test is to verify the structural integrity of a recessed automatic skimmer housing if the skimmer is closed during part of the operating cycle.

### E.1.2 Apparatus

- vacuum source capable of producing a vacuum of 85 kPa (25 in Hg); and
- vacuum gauge accurate to  $\pm 1\%$  and scaled to yield the measurement within 25% to 75% of scale.

### E.1.3 Negative pressure test method

- Assemble skimmer in accordance with the manufacturer's instructions.
- Close the skimmer equalizer inlet. Attach the vacuum source to the skimmer outlet and apply an internal vacuum of  $85 \pm 3.4$  kPa ( $25 \pm 1$  in Hg). Hold the vacuum for at least 5 min.
- Slowly release the vacuum and examine the skimmer housing for evidence of structural failure or other permanent deformation.

### E.1.4 Acceptance criteria

There shall be no evidence of structural failure or permanent deformation of the skimmer housing.

## E.2 Weir opening

### E.2.1 Purpose

The purpose of this test is to verify that a weir will automatically adjust to changes in the water level when operating at the maximum design flow rate.

### E.2.2 Apparatus

- turbidimeter scaled in nephelometric turbidity units (NTU) accurate to  $\pm 2$  NTU;
- temperature-indicating device accurate to  $\pm 1$  °C ( $\pm 2$  °F);
- adequately sized tank and pump to deliver required flow; and
- flow measuring device accurate to  $\pm 3\%$ .

**E.2.3 Test water**

	swimming pools	hot tubs/ spas
water temperature	24 ± 6 °C (75 ± 10 °F)	39 ± 3 °C (102 ± 5 °F)
turbidity	≤ 15 NTU	≤ 15 NTU

**E.2.4 Weir opening test method**

- a) Install the skimmer to the test tank in accordance with the manufacturer's instructions.
- b) Connect a flow meter to the skimmer's outlet port.
- c) Fill the tank to the skimmer's normal operating level and set the flow at the maximum design flow rate.
- d) Slowly raise the water level in the tank until it reaches the maximum level at which the weir will operate. Record this level.
- e) Slowly lower the water level in the tank while observing the water flow over the weir. When the velocity of water traveling over the weir is no longer sufficient to sustain a normal operating level (i.e. lowest overflow level of the weir) in the skimmer throat (and no entrained air observed in suction line), close the drain valve and record the water level in the tank.

**E.2.5 Acceptance criteria**

The difference between the maximum water level and the minimum water level at which the skimmer functions shall be at least 102 mm (4 in), or 76 mm (3 in) if an auto-fill pool water level control device is used.

**E.3 Equalizer leakage test****E.3.1 Purpose**

The purpose of this test is to verify that the leakage of water through the equalizer does not exceed 10% of the total flow through the skimmer under normal operating conditions.

**E.3.2 Apparatus**

- turbidimeter scaled in NTU accurate to ± 2 NTU;
- temperature-indicating device accurate to ± 1 °C (± 2 °F);
- adequately sized tank and pump to deliver required flow; and
- two flow measuring devices accurate to ± 1.5% or ± 4 L/min (± 1 gal/min), whichever is greater.

**E.3.3 Test water**

	swimming pools	hot tubs / spas
water temperature	24 ± 6 °C (75 ± 10 °F)	39 ± 3 °C (102 ± 5 °F)
turbidity	≤ 15 NTU	≤ 15 NTU

**E.3.4 Equalizer leakage test method**

- a) Install the skimmer to the test tank in accordance with the manufacturer's instructions.
- b) Connect one flow meter to the skimmer's equalizer inlet port and one to the skimmer outlet port.
- c) Fill the tank to the skimmer's normal operating level and set the flow at the maximum design flow rate.
- d) Measure the flow rate through the equalizer pipe and the total flow rate through the skimmer. Calculate the percentage of the total flow rate through the skimmer that is admitted through the equalizer pipe.
- e) If the skimmer has an equalizer valve, block 75% of the strainer basket's open area and repeat the steps in annex E, sections E.3.4 c) and d).

**E.3.5 Acceptance criteria**

The flow rate through the equalizer pipe shall not exceed 10% of the total flow rate through the skimmer.

**E.4 Flow to pump test – equalizer performance****E.4.1 Purpose**

The purpose of this test is to verify that a skimmer's equalizer device will prevent air from entering the suction line of the circulation system and will maintain the proper flow rate in the suction line when the water level drops below the lowest overflow level of the skimmer weir.

**E.4.2 Apparatus**

- turbidimeter scaled in NTU accurate to ± 2 NTU;
- temperature-indicating device accurate to ± 1 °C (± 2 °F);
- adequately sized tank and pump to deliver required flow; and
- flow measuring device accurate to ± 3%.

**E.4.3 Test water**

	swimming pools	hot tubs/ spas
water temperature	24 ± 6 °C (75 ± 10 °F)	39 ± 3 °C (102 ± 5 °F)
turbidity	≤ 15 NTU	≤ 15 NTU

#### **E.4.4 Flow to pump – equalizer performance test method**

- a) Install the skimmer to the test tank in accordance with the manufacturer's instructions.
- b) Connect a flow meter to the skimmer's outlet port.
- c) Fill the tank to the skimmer's normal operating level and set the flow at the maximum design flow rate. Observe the return line to the test tank for any signs of air being admitted into the tank. If any air is noted, check the suction line for leaks.
- d) Lower the water level in the tank to  $51 \pm 6.4$  mm ( $2 \pm 0.25$  in) below the lowest overflow level of the weir. There shall be no entrained air observed in the suction line after 30 s from the time the water level drops below the lowest overflow level of the weir. Measure and record the flow rate in the suction line.

#### **E.4.5 Acceptance criteria**

There shall be no entrained air observed in the suction line after 30 s from the time the water level drops below the lowest overflow level of the weir. The flow rate in the suction line shall not deviate from the maximum design flow rate by more than  $\pm 5\%$  from the maximum design flow rate when the water level drops below the lowest overflow level of the weir.

### **E.5 Skimmer covers UV exposure (polymer covers only) and structural integrity.**

#### **E.5.1 Purpose**

To verify the skimmer cover material and design exhibits acceptable weather resistance and structural strength.

#### **E.5.2 Ultraviolet light exposure test (polymer covers only)**

Six (6) new covers (of each material, color, plating or finish) shall be exposed to ultraviolet light and water spray in accordance with ASTM G 154, using the common exposure condition, Cycle 3 found in Table X2.1 of ASTM G 154 for a period of 750 hours. Detachable logo labels or plates shall be removed for this test.

##### **E.5.2.2 Test method**

Specimens shall be mounted inside the test apparatus, with the normally exposed surface of the specimens facing the UV lamps and positioned so they receive exposure approximating an installed cover. After exposure, the skimmer covers shall be kept at ambient temperature and atmospheric pressure for at least 16 hours and not more than 96 hours. The skimmer covers shall then be visually examined for deterioration.

##### **E.5.2.3 Acceptance criteria**

No specimen shall exhibit crazing or cracking. Discoloration shall not be considered unacceptable deterioration. Skimmer covers passing the UV exposure test shall be tested for structural integrity in accordance with E.5.3.

### **E.5.3 Structural integrity**

Six (6) covers which have passed the ultraviolet light exposure test shall be subjected to a Point load and deformation test. Detachable logo labels or plates shall be removed for this test.

#### **E.5.3.1 Test equipment**

A point load machine capable of recording a minimum reading of 2.2 Kg (5 lb) and suitably motorized to apply loads at a rate of 5.08 to 6.35 mm/min (0.20 to 0.25 in/min). Load application accessories include a 2 in. diameter steel Tup with a 2 in.  $\pm$  0.5 in spherical nose radius. And a 50mm (2 in) diameter x 12mm

(0.25 in) thick Buna-N pad of Shore A Durometer  $60 \pm 5$  hardness shall be used between the Tup and cover when applying the point load.

#### **E.5.3.2 Specimen conditioning**

All specimens shall submerged in water at a temperature of  $23 \text{ }^\circ\text{C} \pm 2 \text{ }^\circ\text{C}$  ( $73.4 \text{ }^\circ\text{F} \pm 3 \text{ }^\circ\text{F}$ ) for at least 2 hours before testing. Testing shall proceed immediately upon removing specimens from water.

#### **E.5.3.3 Test fixture**

The covers shall be installed in a rigid fixture capable of supporting the cover in a manner similar to the actual installation. The cover attaching screws shall not be installed.

#### **E.5.3.4 Test method**

Subject the center of cover to a load of  $136 \text{ Kg} \pm 2.2 \text{ Kg}$  ( $300 \text{ lb} \pm 5 \text{ lb}$ ). Test all six (6) specimens.

#### **E.5.3.5 Acceptance criteria**

A skimmer cover shall not deflect more than 9.0 mm (0.35 in). A skimmer cover shall not crack, lose material exclusive of plating or finish, or be permanently deformed (such as geometrical or dimensional deformation).

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## Annex F (normative)

### Test methods for the evaluation of mechanical chemical feeders

NOTE – The test conditions specified in this annex are not intended to represent recommended field use conditions.

## F.1 Hydrostatic pressure test

### F.1.1 Purpose

The purpose of this test is to verify that components of a mechanical chemical feeder that normally operate under pressure can withstand hydrostatic pressure 1.5 times the manufacturer's maximum operating pressure.

### F.1.2 Apparatus

- pressure gauges meeting ANSI B40.100 Grade 3A specifications sized to yield the measurement within 25% to 75% of scale;
- hydrostatic pressure station; and
- thermometer accurate to  $\pm 0.5$  °C ( $\pm 1$  °F).

### F.1.3 Test conditions

	swimming pools	hot tubs / spas
water temperature	$24 \pm 3$ °C ( $75 \pm 5$ °F)	$39 \pm 3$ °C ( $102 \pm 5$ °F)

NOTE – All feeders, except those labeled to be for swimming pools only, shall be tested at the spa/hot tub water temperature.

### F.1.4 Method

- a) Install the feeder in accordance with the manufacturer's instructions.
- b) Fill the feeder with water conditioned to the applicable temperatures specified in annex F, section F.1.3, and bleed off all entrapped air.
- c) Uniformly increase the pressure to obtain 1.5 times the working pressure and hold the pressure for no less than 5 min. Examine the feeder and components for signs of leakage during the test period. Use appropriate protective equipment when examining the feeder.
- d) Slowly release the pressure and examine the unit.

### F.1.5 Acceptance criteria

The mechanical chemical feeder and its integral components shall not rupture, leak, burst, or sustain permanent deformation.

## F.2 Erosion resistance (slurry and dry chemical feeders only)

### F.2.1 Purpose

The purpose of this test is to verify that the materials used in the construction of slurry and dry chemical mechanical feeders have acceptable erosion resistance.

### F.2.2 Apparatus

- pump capable of delivering a minimum 138 kPa (20 psi) back pressure;
- pressure gauge meeting ANSI B40.100 Grade 3A specifications and sized to yield the measurement within 25% to 75% of the scale;
- temperature-indicating device accurate to  $\pm 1$  °C ( $\pm 2$  °F);
- diatomaceous earth; and
- adequately sized recirculation tank and agitation system.

### F.2.3 Test conditions

	swimming pools	hot tubs / spas
water temperature	$24 \pm 3$ °C ( $75 \pm 5$ °F)	$39 \pm 3$ °C ( $102 \pm 5$ °F)

NOTE – All feeders, except those labeled to be for swimming pools only, shall be tested at the spa/hot tub water temperature.

### F.2.4 Method

#### F.2.4.1 Slurry feeders

- a) Assemble the feeder in accordance with the manufacturer's instructions and set it to deliver the maximum rated output.
- b) Fill the recirculation tank with water conditioned to the applicable temperatures specified in annex F, section F.2.3. Add an appropriate amount of diatomaceous earth to the water to obtain a  $5 \pm 0.5\%$  by volume solution.
- c) Start the circulating pump, agitation system, and adjust the throttling valve until the injection head manifold pressure is  $138 \pm 3$  kPa ( $20 \pm 0.5$  psi).
- d) Start the mechanical chemical feeder and allow it to operate continuously for a period of 2500 h. Follow the manufacturer's maintenance instructions, excluding parts replacement, for the duration of the test.

e) Record the maximum output rate per the following schedule:

start of test	sample 1
480 h	sample 2
960 h	sample 3
1440 h	sample 4
1920 h	sample 5
2500 h	sample 6

**F.2.4.2 Dry chemical feeders**

Follow the methods outlined in annex F, section F.2.4.1 using the applicable dry chemical. Perform the test at atmospheric pressure.

**F.2.5 Acceptance criteria**

The maximum output rate as measured in samples 1 through 6 shall be within ± 20% of the manufacturer’s maximum output rate.

**F.3 Chemical resistance**

**F.3.1 Purpose**

The purpose of this test is to determine whether mechanical chemical feeder components that are exposed to the maximum in-use concentrations of the applicable chemical(s) will erode or sustain structural deformation. Following chemical exposure, the accuracy of the feed rate indicator is determined.

**F.3.2 Test solutions**

	swimming pools	hot tubs / spas
water temperature	24 ± 6 °C (75 ± 10 °F)	39 ± 3 °C (102 ± 5 °F)
test chemical	the maximum in-use concentration of the manufacturer's recommended chemical(s)	the maximum in-use concentration of the manufacturer's recommended chemical(s)

NOTE 1 – All feeders, except those labeled to be for swimming pools only, shall be tested at the spa/hot tub water temperature.

NOTE 2 – The test temperature may be obtained by heating or cooling the test water solution or by heating or cooling the ambient temperature around the chemical feeding equipment.

**F.3.3 Method**

- a) Seal the inlet and discharge ends of the mechanical chemical feeder(s) and introduce the maximum in-use concentration of exposure chemical.
- b) Expose all normally wetted parts of the feeder to the applicable chemical solution for a period of 100 d ± 6 h at the ambient temperature specified in annex F, section F.3.2.

- c) Flush the exposure chemical from the feeder and operate it at 100% of its rated capacity for  $24 \pm 1$  h according to the manufacturer’s instructions.
- d) After the 24 h period, evaluate the feeder output uniformity at 100% of its rated capacity by using the method in annex F, section F.5.

**F.3.4 Acceptance criteria**

After chemical exposure, mechanical chemical feeders shall show no signs of erosion or structural deformation and shall deliver an output rate within  $\pm 10\%$  of the manufacturer’s maximum rated capacity.

**F.4 Life test**

**F.4.1 Purpose**

The purpose of this test is to evaluate the durability of mechanical chemical feeders used in pool and spa/hot tub applications.

**F.4.2 Apparatus**

- pump capable of delivering a sufficient back pressure;
- pressure gauge meeting ANSI B40.100 Grade 3A specifications and sized to yield the measurement within 25% to 75% of scale;
- temperature-indicating device accurate to  $\pm 1$  °C ( $\pm 2$  °F); and
- recirculation tank.

**F.4.3 Water temperature**

	swimming pools	hot tubs / spas
water temperature	$24 \pm 3$ °C ( $75 \pm 5$ °F)	$39 \pm 3$ °C ( $102 \pm 5$ °F)

NOTE – All feeders, except those labeled to be for swimming pools only, shall be tested at the spa/hot tub water temperature.

**F.4.4 Method**

- a) Assemble three feeders according to the manufacturer’s instructions.
- b) Connect the feeders to a recirculating tank filled with water conditioned to the applicable temperatures specified in annex F, section F.4.3. Adjust the pressure source to obtain an injection head manifold pressure that is  $80 \pm 0.5\%$  of the maximum rated pressure. Set the output rate to deliver the maximum rated output specified by the manufacturer.
- c) Start the feeders and allow them to operate continually for a period of 3000 h. Maintain the feeders in accordance with the manufacturer’s instructions, except for parts replacement. (Tubing in a peristaltic feeder may be replaced every 500 h or at 120% of the rated life expectancy, whichever is greater).

**F.4.5 Acceptance criteria**

At least one of the three mechanical chemical feeders shall complete 3000 satisfactory operating hours, and a minimum of 8000 satisfactory operating hours shall be accumulated among the three units. At the conclusion of the testing, the units shall perform as intended by the manufacturer and shall continue to conform to the uniformity of output requirements in annex F, section F.5.

**F.5 Uniformity of output test**

**F.5.1 Purpose**

The purpose of this test is to verify that the chemical delivery rates of mechanical feeders are consistent with delivery rates claimed by the manufacturer at the various feed rate indicator settings.

**F.5.2 Apparatus**

- 19-L (5-gal) container;
- stopwatch;
- injection manifold with pressure tap and throttling valve;
- pressure gauge meeting ANSI B40.100 Grade 3A specifications and sized to yield the measurement within 25% to 75% of scale;
- pump capable of delivering sufficient back pressure; and
- scale accurate to  $\pm 0.005$  kg ( $\pm 0.01$  lb).

**F.5.3 Water temperature**

	swimming pools	hot tubs / spas
water temperature	$24 \pm 3$ °C ( $75 \pm 5$ °F)	$39 \pm 3$ °C ( $102 \pm 5$ °F)

NOTE – All feeders, except those labeled to be for swimming pools only, shall be tested at the spa/hot tub water temperature.

**F.5.4 Method**

NOTE – The method described here is primarily intended for the testing of high-flow peristaltic pumps. Some modification may be required when evaluating other types of mechanical feeder designs, including those whose feed rates are not continuous over the course of operation. Modifications may be made so that the intent of the method is maintained.

- a) Assemble the mechanical chemical feeder in accordance with the manufacturer's instructions and set it to deliver 100% of its capacity.
- b) Attach the mechanical chemical feeder discharge line to the injection manifold.
- c) Fill the 19-L (5-gal) container with water conditioned to the temperature specified in annex F, section F.5.3. Place the container on the scale and position the mechanical chemical feeder even with the water level in the container.

- d) Fully prime the mechanical chemical feeder according to the manufacturer's instructions.
- e) Start the recirculation pump and adjust the back pressure to the maximum pressure specified by the manufacturer's delivery output curve  $\pm 0.25\%$ .
- f) Note the weight ( $W_1$ , in lb or Kg) on the scale while starting the stopwatch. Allow the mechanical feeder to operate for  $1 \text{ h} \pm 6 \text{ min}$ . Note the weight ( $W_2$ , in lb or Kg) on the scale.
- g) Calculate the delivery as follows:

$$\text{delivery (gpm)} = [(W_1 - W_2)/8.33]/\text{time}$$

or

$$\text{delivery (Lpm)} = [(W_1 - W_2)/(1 \text{ Kg}/1 \text{ L})]/\text{time}$$

- h) Repeat steps in annex F, section F.5.4 c) through g) at 25%, 50%, and 75% of the feeder's rated capacity.

### F.5.5 Acceptance criteria

Mechanical chemical feeders shall deliver chemicals at an output rate that is  $\pm 10\%$  of the feed rate indicator setting over deliveries from 25% to 100% rated capacity.

## F.6 Suction lift test

### F.6.1 Purpose

The purpose of this test is to determine the amount of chemical delivered by a positive displacement mechanical feeder that is subject to a suction lift of 1.2 m (4 ft), in order to verify the delivery rate claimed by the manufacturer.

### F.6.2 Apparatus

- 19-L (5-gal) container;
- stopwatch;
- injection manifold with pressure tap and throttling valve;
- pressure gauge meeting ANSI B40.100 Grade 3A specifications and sized to yield the measurement within 25% to 75% of scale;
- measuring device accurate to 1.6 mm (0.0625 in);
- recirculation tank with a pump capable of delivering sufficient back pressure; and
- scale accurate to  $\pm 0.005 \text{ kg}$  ( $\pm 0.01 \text{ lb}$ ).

**F.6.3 Water temperature**

	swimming pools	hot tubs / spas
water temperature	24 ± 3 °C (75 ± 5 °F)	39 ± 3 °C (102 ± 5 °F)

NOTE – All feeders, except those labeled to be for swimming pools only, shall be tested at the spa/hot tub water temperature.

**F.6.4 Method**

NOTE – The method described here is primarily intended for the testing of high-flow peristaltic pumps. Some modification may be required when evaluating other types of mechanical feeder designs, including those whose feed rates are not continuous over the course of operation. Modifications may be made so that the intent of the method is maintained.

- a) Assemble the mechanical chemical feeder in accordance with the manufacturer's instructions and set it to deliver 100% of its capacity.
- b) Attach the mechanical chemical feeder discharge line to the injection manifold.
- c) Fill the 19-L (5-gal) container with water conditioned to the temperature specified in annex F, section F.6.3. Place the container on the scale and position the mechanical chemical feeder 1.2 m (4 ft) above the water level in the container.
- d) Fully prime the mechanical chemical feeder according to the manufacturer's instructions.
- e) Start the recirculation pump and adjust the back pressure to 80% of the maximum pressure specified on the manufacturer's delivery output data plate.
- f) Note the weight ( $W_1$ ) on the scale while starting the stopwatch. Allow the mechanical feeder to operate for 1 h ± 6 min. Note the weight ( $W_2$ ) on the scale.
- g) Calculate the delivery as follows: Delivery (gpm) =  $[(W_1 - W_2)/8.33]/\text{Time}$  or see annex F, section F.5.4 g).

**F.6.5 Acceptance criteria**

Positive displacement pump mechanical feeders operating with a suction lift of 1.2 m (4 ft) of water, at 80% back pressure and 100% of their rated capacity, shall deliver an output rate that is within ± 10% of the delivery specified by the manufacturer.

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## Annex G (normative)

### Test methods for the evaluation of flow-through chemical feeding equipment

NOTE – The test conditions specified in this annex are not intended to represent recommended field use conditions.

## G.1 Chemical resistance test

### G.1.1 Purpose

The purpose of this test is to determine whether flow-through chemical feeder components that are exposed to the maximum in-use concentration of the applicable chemical(s) will erode or display structural deformation.

### G.1.2 Test solution

The test solution shall consist of the manufacturer's recommended maximum in-use concentration of the chemical(s) specified for use with the feeders.

### G.1.3 Ambient temperature

	swimming pools	hot tubs / spas
water temperature	$24 \pm 3 \text{ }^{\circ}\text{C}$ ( $75 \pm 5 \text{ }^{\circ}\text{F}$ )	$39 \pm 3 \text{ }^{\circ}\text{C}$ ( $102 \pm 5 \text{ }^{\circ}\text{F}$ )

NOTE – The test temperatures may be achieved by heating or cooling the test water solution or by heating or cooling the ambient temperature around the chemical feeding equipment.

### G.1.4 Chemical resistance test method

NOTE – The method described here is primarily intended for the testing of basic erosion-type flow-through chemical feeders. Some modification may be required when evaluating differing types of flow-through chemical feeder designs. However, the intent of the method shall be maintained when these modifications are made.

- a) Fill the flow-through chemical feeder to the maximum level with the applicable chemicals, or subject feeder parts to the specified chemicals by immersion. If the chemical is a dry type, fill the feeder to the manufacturer's maximum recommended chemical level and then fill it to the maximum water level.
- b) Ensure that the chemical solution is in contact with each surface that is to be exposed.
- c) Seal all inlet and outlet ports, with the exception of one port above the flood level to allow any generated gases to escape.
- d) Expose the normally wetted parts to the chemical(s) for  $100 \text{ d} \pm 6 \text{ h}$ .
- e) Examine the feeder weekly and check for any signs of leakage, damage, or any other noticeable changes. Once the test period has elapsed, drain and examine the feeder.

**G.1.5 Acceptance criteria**

Wetted parts of the feeder shall show no signs of deterioration or structural deformation.

**G.2 Hydrostatic pressure test****G.2.1 Purpose**

The purpose of this test is to ensure that a flow-through chemical feeder and its components can withstand hydrostatic pressure 1.5 times the manufacturer's working pressure.

**G.2.2 Apparatus**

- hydrostatic pressure station;
- pressure gauges meeting ANSI B40.100 Grade 3A specifications and sized to yield the measurement within 25% to 75% of scale; and
- thermometer accurate to  $\pm 0.5$  °C ( $\pm 1$  °F).

**G.2.3 Water temperatures**

	swimming pools	hot tubs / spas
water temperature	$24 \pm 3$ °C ( $75 \pm 5$ °F)	$39 \pm 3$ °C ( $102 \pm 5$ °F)

**G.2.4 Hydrostatic pressure test method**

NOTE –The method described here is primarily intended for the testing of basic erosion-type flow-through chemical feeders. Some modification may be required when evaluating differing types of flow-through chemical feeder designs. However, the intent of the method shall be maintained when these modifications are made.

- a) Install the feeder in accordance with the manufacturer's instructions.
- b) Fill the feeder with water conditioned to the applicable temperature specified in G.2.3, and bleed off any entrapped air.
- c) Uniformly increase the pressure to obtain 1.5 times the working pressure to the filter housing and components, and hold the pressure for no less than 5 min. Examine the feeder and components for signs of leakage during the test period.
- d) Slowly release the pressure and examine the unit.

**G.2.5 Acceptance criteria**

The flow-through feeder and its integral components shall not rupture, leak, burst, or sustain permanent deformation.

### G.3 Uniformity of output test

#### G.3.1 Purpose

The purpose of this test is to determine the amount of chemical delivered by a flow-through chemical feeder in order to verify the delivery rates claimed by the manufacturer.

#### G.3.2 Apparatus

- pH-indicating device accurate to  $\pm 0.1$ ;
- temperature-indicating device accurate to  $\pm 1$  °C ( $\pm 2$  °F);
- tank with a supply pump;
- titration device accurate to  $\pm 1\%$  of reading, (if none is commercially available with this accuracy, the method inaccuracy shall be included in the tolerance of the output rate);
- timing device accurate to  $\pm 1\%$  over test duration; and
- flow meter accurate to  $\pm 2\%$ .

#### G.3.3 Test waters

temperature	swimming pools	$27 \pm 2$ °C ( $80 \pm 3$ °F)
	spas	$38 \pm 2$ °C ( $101 \pm 3$ °F)
pH	pools/spas	Ca, Na, Li – hypochlorites: pH 7.2-7.6
		ISOs: pH 7.2-7
alkalinity	pools/spas	Ca, Na, Li – hypochlorites: 60-100 ppm (CaCO <sub>3</sub> )
		ISOs: 80-120 ppm (CaCO <sub>3</sub> )
hardness	pools/spas	200-400 ppm (CaCO <sub>3</sub> )
combined chlorine	pools/spas	< 0.2 ppm
ammonia	pools/spas	< 0.04 ppm (as N)

#### G.3.4 Uniformity of output test method for feeder settings resulting in more than 2.2 lbs/d output

##### G.3.4.1 Method

NOTE – The method described here is primarily intended for the testing of basic erosion-type flow-through chemical feeders. Some modification may be required when evaluating differing types of flow-through chemical feeder designs. However, the intent of the method must be maintained when these modifications are made.

- a) Install the flow-through chemical feeder in accordance with the manufacturer's instructions, with its influent connected to the discharge side of the supply pump and its effluent directed to drain. Position a flow meter inline with the feeder.
- b) Fill the tank with water conditioned to parameters specified in annex G, section G.3.3. Fill the feeder with the maximum amount of recommended chemicals.
- c) Condition the feeder for  $10 \text{ min} \pm 30 \text{ s}$  by running the appropriate test water through the feeder at the maximum (100%) output rate control mechanism setting.

- d) Allow the feeder to operate at the maximum output rate control mechanism setting for 1 h ± 6 min. Sample both the influent and the effluent from the feeder and determine the concentration of active chemical being dispensed after the 1-h conditioning period. This sample will provide the first of five sample points used to determine repeatability.
- e) Continue operating the feeder at the maximum output rate control mechanism setting, and sample both the influent and the effluent of the feeder four times so that each sample is taken at a 5-min interval. Determine the concentration of the active chemical in each influent and effluent sample. These data will be used to determine repeatability.
- f) Repeat d) and e) at 50% of the output rate control mechanism setting.
- g) Calculate the net output concentration at each sampling interval by subtracting the influent concentration from the effluent concentration. Convert the net output concentration to the units with which the manufacturer specifies the output rate for the feeder.

#### **G.3.4.2 Acceptance criteria**

**G.3.4.2.1** At each test setting of the output rate control mechanism, individual output rates shall be within ± 20% of the manufacturer's claim.

**G.3.4.2.2** Individual output rates shall be within ± 10% of the average of all taken at a test setting.

#### **G.3.5 Uniformity of output test method for feeder settings resulting in less than 2.2 lbs/d output**

##### **G.3.5.1 Method**

- a) Install the flow-through chemical feeder in accordance with the manufacturer's instructions, with its influent connected to the discharge side of the recirculating pump and its effluent connecting back to the supply tank. Position a flow meter in line with the feeder.
- b) Fill the tank with water conditioned to parameters specified in annex G, section G.3.3. Fill the feeder with the maximum amount of recommended chemicals.
- c) Disconnect the effluent line from the feeder and direct it to drain during conditioning. Condition the feeder for 10 min ± 30 s by running the appropriate test water through the feeder at 100% of the maximum output rate control mechanism setting. Reconnect the effluent line to the tank.
- d) Collect an initial control sample from the tank.
- e) Allow the feeder to operate at 100% of the maximum output control mechanism setting for 1 h ± 6 min. Collect an effluent sample from the tank and determine the concentration of free chlorine (ppm).
- f) Continue to collect one output sample at each additional hour ± 6 min for a total of 6 h.
- g) Repeat steps d), e), and f) at 50% of the maximum output rate control mechanism setting.
- h) Calculate the net increase in concentration (ppm) per hour for each sample point.
- i) Interpolate the output rate after 24 h. Convert the net output concentration to the units with which the manufacturer specifies the output rate for the feeder.

**G.3.5.2 Acceptance criteria**

At each test setting of the output rate control mechanism, individual output rates shall be within  $\pm 20\%$  of the manufacturer's claim.

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## Annex H (normative)

### Test methods for the evaluation of process equipment

#### H.1 Disinfection efficacy of supplemental disinfection equipment

##### H.1.1 Purpose

The purpose of this test is to determine the disinfection efficacy of process equipment designed for supplemental disinfection for swimming pools and spa/hot tubs.

##### H.1.2 Apparatus

See figure H1 in this annex.

##### H.1.3 Specific test waters

a) The test water shall be balanced prior to the addition of challenge constituents and microorganisms. The water shall have the following characteristics.

pH	pools/spa	7.2–7.6
alkalinity	pools/spa	60 - 100 ppm (CaCO <sub>3</sub> )
hardness	pools/spa	200 - 400 ppm (CaCO <sub>3</sub> )

b) The following elements shall be added to the test waters while the disinfection efficacy of the process equipment is determined:

- grease and oil as 18–22 mg/L baby oil;
- Kjeldahl nitrogen as 8.5–9.0 mg/L urea; and
- two microbiological organisms, *Enterococcus faecium* (strain PRD American Type Culture Collection [ATCC] #6569, formerly *Streptococcus faecalis*) and *Pseudomonas aeruginosa* (ATCC #27313)<sup>25</sup>.

##### H.1.4 Analytical methods

The analytical methods shall be those specified in *Standard Methods for the Examination of Water and Wastewater*.

<sup>25</sup> American Type Culture Collection, P. O. Box 1549, Manassas, VA 20108

## H.1.5 Culture of bacteria

### H.1.5.1 Preparation and preservation of stock

- a) Purchase freeze-dried *E. faecium* and *P. aeruginosa* from ATCC.
- b) Revive the freeze-dried cultures according to the directions supplied with the culture and in the current ATCC *Catalog of Strains*. At least three consecutive (maximum of 30) daily transfers shall be performed prior to the preparation of the test challenge.
- c) Confirm the purity of the revived challenge strains through streak plating on appropriate growth media. Confirm the biochemical and physical profile of the resulting isolates through Gram Staining, oxidase assay, catalase assay, or other valid biochemical tests.

### H.1.5.2 Preparation of test challenge

- a) From the stock cultures, inoculate a tube of Tryptic Soy Broth (TSB) for *P. aeruginosa* and a tube of Brain Heart Infusion Broth for *E. faecium*.
- b) Inoculate the entire surface of ten fresh Tryptic Soy agar (TSA) slants with 1 mL of *P. aeruginosa* broth culture. Inoculate twenty Brain Heart Infusion (BHI) agar slants with 1 mL of *E. faecium*. Incubate  $24 \pm 2$  h at  $35 \pm 2^\circ\text{C}$  ( $95 \pm 2^\circ\text{F}$ ) the day before testing.
- c) Suspend the growth from the agar slant of *P. aeruginosa* and *E. faecium* by adding 5 mL of sterile buffered distilled or deionized water (SBDW) and gently scraping using a sterile loop.
- d) Maintain the bacteria suspensions at 1 to 5 °C (32 to 41 °F) no longer than 24 h before use.
- e) Perform standard plate count to determine cell density. The standard plate count shall be performed within 1 h of use. Both bacterial suspensions should be approximately  $1.0 \times 10^{10}$  colony forming units (CFU) per mL.

### H.1.5.3 Analyzing of samples obtained during testing

Samples shall be analyzed in accordance with *Standard Methods for the Examination of Water and Wastewater*.

## H.1.6 Evaluation

### H.1.6.1 Test apparatus

- a) Calculate the water volume sufficient to provide at least five turnovers in 30 min through the unit under test. If the unit under test does not turn the water over, then use a volume that can be disinfected in 30 min based on the manufacturer's recommendation (minimum of 211 gal [800 L]).
- b) Empty and thoroughly clean a test vessel capable of holding the water volume calculated in annex H, section H.1.6.1 a).
- c) Provide a heating and mixing mechanism for the vessel referred to in annex H, section H.1.6.1 b).
- d) Fill the test vessel with deionized water, the volume specified in annex H, section H.1.6.1 a). Condition per annex H, section H.1.3 a).

- e) Measure and record pH, free chlorine, and turbidity. Do not add microorganisms to test water until the turbidity is less than 2.0 NTU.

#### H.1.6.2 Procedure

- a) Use the test apparatus and water volume specified in annex H, section H.1.6.1.
- b) Activate circulation and heater systems to attain a stabilized temperature of 18 to 29°C (65 to 85 °F).
- c) Ensure that the system under test is operating per the manufacturer's instructions.
- d) Turn off the system under test.
- e) Collect three test water samples (see annex H, table H.1) and determine the background concentrations of *P. aeruginosa* and *E. faecium* using methods described in *Standard Methods*. All microbiological samples shall be collected using sterile sample bottles containing appropriate neutralizing solution.

NOTE – Example neutralizers such as, but not limited to the following shall be considered appropriate; Halogen based disinfectants utilizing Sodium thiosulfate or Lethen broth; Metal ion based disinfectants utilizing Chambers solution (5% thiosulfate and 7.3% thioglycollate).

- f) The constituents specified in annex H, section H.1.3 b) shall be added simultaneously to the test water. Add an appropriate amount of the appropriate challenge organism to obtain a minimum of  $1.0 \times 10^6$  organisms per 100 mL of test water (not to exceed  $1.0 \times 10^7$  per 100 mL per each challenge organism). Allow an appropriate period of time for the organisms to reach a homogenous dispersion state within the test tank (for 30 min). Take 3 control samples (see annex H, table H.1).

##### H.1.6.2.1 Testing of the sample

- a) Activate the system under test and start a stopwatch. Sampling shall occur after each tank volume turnover until all 5 turnovers are completed (see annex H, table H.1). If the system does not turn the water over, use the sampling procedure outlined in annex H, section H.1.6.1a), collecting the triplicate samples after 30 min.
- b) Samples shall be collected out of the return line downstream from the system under test and before the tank (see annex H, figure H.1). Collect all samples in triplicate.
- c) Process all samples as described in *Standard Methods for the Examination of Water and Wastewater* within 1 h of collection.
- d) Obtain a separate geometric mean for all triplicate samples taken at each individual time point.
- e) Determine the log reduction at each sample time by using the following equation:

$$\text{Log Reduction} = \log_{10}(N_s / N_o)$$

$N_s$  = sample geometric mean

$N_o$  = calculated target challenge concentration (mean of triplicate samples from annex H, section H.1.6.2. e).

### H.1.6.3 Acceptance criteria

After each of five complete turnovers, the test unit shall achieve a 3 log reduction for both challenge organisms.

NOTE – If the test unit does not turn the water over, the samples taken at 30 min shall demonstrate a 3 log reduction.

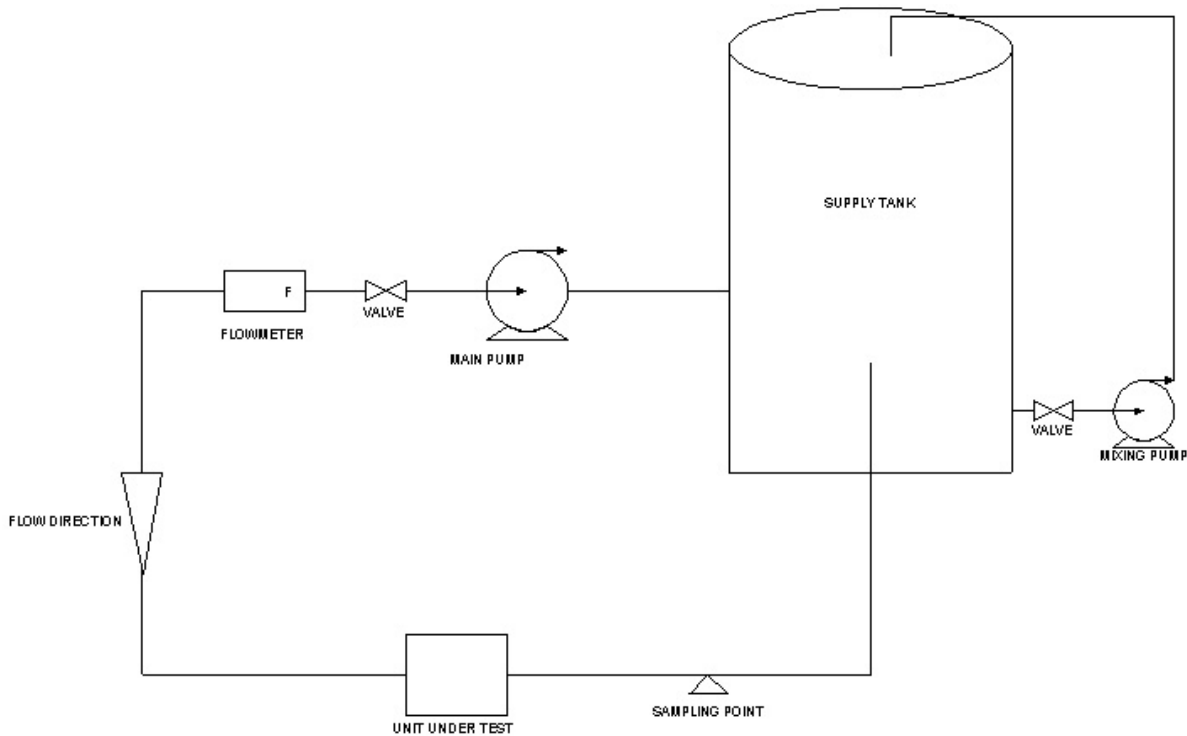


FIGURE H1  
APPARATUS TO ILLUSTRATE SAMPLING POINT

## H.2 Ozone level test

### H.2.1 Purpose

The purpose of this test is to verify that an ozone process device does not allow for the passing of ozone into the pool and spa/hot tub water above acceptable limits.

### H.2.2 Apparatus

See figure H1 in this annex.

### H.2.3 Test water

The test water shall be as specified in section H.1.3 of this annex, but shall not include the elements added to simulate an organic and microbiological load.

#### **H.2.4 Method**

Install the ozone device in accordance with the manufacturer's instructions, and operate the unit until a steady state condition exists and the maximum ozone output rate is reached.

Continue operating the system for 1 h, measuring the ozone level in the test vessel water at 15-min intervals.

#### **H.2.5 Acceptance**

At no time during the test shall the ozone concentration in the test vessel water exceed 0.1 ppm.

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Table H.1 – Disinfection efficacy sampling sequence

Sample number	Description of sampling event	# organisms/100 mL Enterococcus faecium	# organisms/100 mL Pseudomonas aeruginosa
1	tank prior to inoculation (1) annex H, section H1.6.2 e)		
2	tank prior to inoculation (2) annex H, section H1.6.2 e)		
3	tank prior to inoculation (3) annex H, section H1.6.2 e)		
4	tank after inoculation and mixing – before start of device (1) annex H, section H1.6.2 f)		
5	tank after inoculation and mixing – before start of device (2) annex H, section H1.6.2 f)		
6	tank after inoculation and mixing – before start of device (3) annex H, section H1.6.2 f)		
7	effluent after first turnover (1) annex H, section H1.6.2.1 a)		
8	effluent after first turnover (2) annex H, section H1.6.2.1 a)		
9	effluent after first turnover (3) annex H, section H1.6.2.1 a)		
10	effluent after second turnover (1) annex H, section H1.6.2.1 a)		
11	effluent after second turnover (2) annex H, section H1.6.2.1 a)		
12	effluent after second turnover (3) annex H, section H1.6.2.1 a)		
13	effluent after third turnover (1) annex H, section H1.6.2.1 a)		
14	effluent after third turnover (2) annex H, section H1.6.2.1 a)		
15	effluent after third turnover (3) annex H, section H1.6.2.1 a)		
16	effluent after fourth turnover (1) annex H, section H1.6.2.1 a)		
17	effluent after fourth turnover (2) annex H, section H1.6.2.1 a)		
18	effluent after fourth turnover (3) annex H, section H1.6.2.1 a)		
19	effluent after fifth turnover (1) annex H, section H1.6.2.1 a)		
20	effluent after fifth turnover (2) annex H, section H1.6.2.1 a)		
21	effluent after fifth turnover (3) annex H, section H1.6.2.1 a)		

## Annex I<sup>26</sup>

### Process equipment – recommendations for installation and operation

#### I.1 Introduction

The purpose of this annex is to provide general recommendations for the installation and operation of process equipment to obtain satisfactory performance. The actual method of installation and operation should comply with the manufacturer's recommendations and with the applicable state and local laws and regulations.

#### I.2 Pool water balance

In order to ensure the satisfactory performance of the process equipment, it is important to maintain a balanced pool water chemistry. Specific devices may have special needs in relation to the pool water balance. The operation and installation instructions provided with the device should be consulted.

#### I.3 Testing frequencies

Testing of the pool water should be conducted on a routine and frequent basis to ensure that appropriate parameters are being maintained and also to provide an adequate record of the daily operation of the pool. The regulatory agency having jurisdiction should be consulted to determine the minimum frequency of testing that is required.

#### I.4 In-line electrolytic and brine-type chlorine generators

##### I.4.1 Pool chemistry

Before the chlorine generator is placed into service, the pool should be chemically balanced. In-line systems will require a minimum chloride level as specified by the manufacturer.

Stabilizing of the chlorine residual may be accomplished with the use of cyanuric acid, which prevents the rapid breakdown of chlorine. Applicable state or local regulations should be consulted pertaining to the use of cyanuric acid.

##### I.4.1.1 Sizing a chlorinator system

When sizing a chlorinator system for a pool or spa, one should consider the typical and worst-case loads on the pool/spa disinfection system. One should account for relevant variables such as excessive bather load, excessive temperature, excessive aeration of water, and above all, local code requirements.

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#### **I.4.1.1.1 Sizing a pool chlorinator system**

Chlorine chemical generators and feeders for pool chlorinator systems should be capable of supplying no less than 3 lbs of chlorine per day, per 10,000 gallons.

#### **I.4.1.1.2 Sizing a spa chlorinator system**

Chlorine chemical generators and feeders for spa chlorinator systems should be capable of supplying no less than 3 lbs of chlorine per day, per 1,000 gallons.

### **I.4.2 Installation**

Due to the varied designs available, it is difficult to provide general installation guidelines. The system should be installed in accordance with the manufacturer's instructions and state and local regulatory agency regulations.

To avoid the release of chlorine gas or potential equipment corrosion, it is important to protect the system from loss of water flow. Electrolytic chlorinators should have the power source to the chlorinator interconnected with the power source for the pump. For brine-type systems, the release of chlorine gas into the piping system may be prevented by the installation of an acceptable vacuum breaker downstream of the system.

### **I.4.3 Operation**

To ensure adequate operation of the system, the user should clearly understand and follow the manufacturer's recommendations for monitoring of water chemistry and routine maintenance.

Whenever one is working with chlorine, especially in the gas state, it is important to follow proper safety precautions. The user should refer to the manufacturer's recommendations and to the federal, state, and local regulations that may apply.

Chlorine gas is considered toxic. Adequate ventilation should be provided when a system is located in an enclosed area.

## **I.5 Ozone process equipment**

### **I.5.1 Background**

There are two systems typically used for generating ozone (O<sub>3</sub>) on-site at the pool facility. One system pumps air past ultraviolet light (UV) to generate the ozone. The second system, the corona discharge method, utilizes an applied voltage across an air gap to ionize the oxygen molecules. The type of system required will depend on the amount of ozone required. Corona discharge units will typically generate larger quantities of ozone.

### **I.5.2 Residual disinfection**

Ozone is a very efficient oxidizing agent. However, it is very difficult to maintain a measurable ozone residual in the pool water. It is recommended that a chemical such as chlorine or bromine be added after treatment with ozone as a residual disinfectant, at levels mandated by state and local regulations. The oxidizing of organics by ozone prior to application of the residual disinfectant helps prevent the formation of undesirable halogenated byproducts.

There are ozone removal methods that may be considered prior to the addition of the chemical disinfectant:

- degassing by means of aerated flow; and
- granular activated carbon filter.

Ozone process equipment should be placed upstream of the ozone removal methods cited above. Halogenation equipment should be placed downstream of ozone removal methods.

### **I.5.3 Off-gassing**

Ozone is considered toxic above certain concentrations in air. If the ozone concentration in the water exceeds the equilibrium state, the excess ozone will be emitted into the air. The Occupational Safety and Health Administration has set a short-term exposure limit of 0.3 ppm (0.6 mg/m<sup>3</sup>) and 0.1 ppm (0.2 mg/m<sup>3</sup>) time weighted average, over 8 h/d, 5 d/week.

When the equipment is located in an enclosed room, consideration should be given to having adequate exhaust in case of ozone releases. The exhaust system should provide a minimum of three air changes per hour to comply with the OSHA limits. In addition, an ambient air ozone monitor should be installed. Ozonation systems, which operate under vacuum, should not present a danger of ozone leaks into the treatment room.

### **I.5.4 Oxidation-reduction potential (ORP)**

The oxidation-reduction potential (ORP) in swimming pool and spa sanitation is defined as the ORP (millivolts) produced by the strong oxidizing sanitizers into water. ORP provides a direct indication of the activity of a sanitizer, but does not measure disinfectant residual. ORP monitoring devices should be used to monitor the ozone system.

## **I.6 Copper/silver and copper ion generators**

### **I.6.1 Halogen levels**

These systems are intended for the supplemental treatment of the water, not the replacement of the disinfecting halogen being used (e.g., chlorine, bromine). The halogen levels in the pool, along with the copper levels, should be maintained at levels required by state or local regulations, to ensure adequate disinfection.

### **I.6.2 Other chemical agents**

When copper-based algaecides are used, care should be taken that the total copper ion levels in the pool do not exceed the maximum limits required by state and local regulations.

Superchlorination of a pool may cause precipitation of the copper and silver ions present in the water. The manufacturer's recommended procedures should be followed to avoid the possibility of staining.

## **I.7 Ultraviolet light process equipment**

### **I.7.1 Halogen levels**

Ultraviolet light process systems are intended for the supplemental treatment of the water, not the replacement of the disinfecting halogen being used (e.g., chlorine or bromine). The halogen levels in the

pool, along with the copper levels, should be maintained at levels required by state and local regulations, to ensure adequate disinfection.

### **I.7.2 Installation**

UV treatment equipment may deplete halogen levels; therefore, UV treatment equipment should be placed upstream of halogenation equipment.

It is recommend that UV systems be installed in the main line or in accordance with the manufacturer's instructions and state and local regulations. The UV unit can be fitted in a bypass, but during operation the bypass should be fully closed to ensure full treatment of all the water.

It is also recommended that an appropriate strainer be fitted downstream of the UV unit.

Valves placed in close proximity to, and in the line of sight of, the UV lamp should have metal discs, and should be uncoated or of a material that the manufacturer can confirm as UVC stable.

Pipework adjacent to the UV unit should be of a suitable material. ABS should not be used.

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## Annex J<sup>27</sup>

### Recessed automatic surface skimmers recommendations for installation and operation<sup>28</sup>

This is not a basic part of the Standard nor the responsibility of the manufacturer. However, to obtain satisfactory performance and proper results, the following limitations should be considered in the overall hydraulic design of the pool, spa, or hot tub. The method of installation and operation should conform to the manufacturer's recommendations and the applicable state and local laws and regulations.

Skimmers may be installed in public swimming pools on the basis of 46.5 m<sup>2</sup> (500 ft<sup>2</sup>) of water surface area per unit, or fraction thereof; for residential swimming pools, on the basis of 74.4 m<sup>2</sup> (800 ft<sup>2</sup>) of water surface area per unit or fraction thereof; or for spas or hot tubs, on the basis of 9.3 m<sup>2</sup> (100 ft<sup>2</sup>) of surface area or fraction thereof. Where unusual shapes of pools are encountered, special consideration should be given to the number of skimmers used. The required skimmers should be distributed to ensure effective skimming of the entire surface. Their location should also take into consideration the pool, spa, or hot tub shape, prevailing winds, and circulation patterns in the pool, spa, or hot tub. Return inlets should be sized to provide an inlet velocity of at least 3 m (10 ft) per second for good mixing and proper dispersal of return water. Return inlets should provide circulation patterns toward skimmers to improve surface drift.

Skimmers should be built into the pool, spa, or hot tub walls with no protrusions beyond the face (except for the faceplate) or above the deck. The throat of flap-type weirs should not be narrower than the skimming weir. Skimmers should be accurately positioned to ensure that the average operating water level occurs at the midpoint of weir operating range.

Piping for skimmers should have a minimum capacity of 80% for public and 50% for residential pools, spas, or hot tubs of the required filter flow, and it should not be less than 75.6 Lpm (20 gpm) per skimmer. In pools, spas, or hot tubs having capacities of less than 60,480 L (16,000 gal) and surface areas of less than 46.5 m<sup>2</sup> (500 ft<sup>2</sup>), flow rates should not be reduced even if the total turnover period of the pool, spa, or hot tub is shortened. In multiple installations, each skimmer should not be individually adjustable for flow. Single skimmers without integral trimmer valves should be installed to facilitate the balancing of flow between the skimmer and the main outlet.

Strainer baskets, when provided, should be cleaned regularly for proper performance. Clogged baskets impair the flow and free action of the weir, resulting in nonperformance.

Skimmer weirs should be checked routinely for attachment to housing and proper action.

Direct addition of acids, alum, chlorine solution or powders, and other chemicals will seriously corrode valves, tanks, screens, and other metal parts of skimmers and related circulation components, and should not be performed.

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<sup>28</sup> This subject is currently under review by the American Public Health Association (APHA) Joint Committee. When the APHA code is changed, annex J will be revised to be consistent with the code.

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## Annex K<sup>29</sup>

### Diatomite-type filters recommendations for installation and operation

This is not a basic part of the Standard, nor the responsibility of the manufacturer. To obtain proper results, the following limitations should be considered in overall hydraulic design of the pool, spa, or hot tub. Diatomite-type filters fabricated according to this Standard will perform satisfactorily when installed and connected according to the manufacturer's recommendations. Installation and operation should comply with the applicable state and local laws and regulations.

## K.1 Recommended installation

### K.1.1 Turnover

Turnover will vary depending on classification of pool, spa, or hot tub bathing load and use in the following ranges:

- heavily used public pools – not more than 6 h;
- other public pools – not more than 8 h;
- residential pools – not more than 12 h;
- public spas or hot tubs – not more than 30 min; and
- residential spas or hot tubs – not more than 1 h.

### K.1.2 Pumps

#### K.1.2.1 Pressure filters

Pumps should be selected to meet design flow and backwash rates under use conditions. Sufficient reserve head should be provided to overcome friction losses in piping and appurtenances through which water flows after discharge from the pump and returning to the pool, spa, or hot tub. Pumps should be matched to the filter units.

#### K.1.2.2 Vacuum filters

Vacuum filters should have a pump capable of delivering the design flow rate at a suction of at least 508 mm (20 in) of mercury<sup>30</sup> without cavitation. Sufficient reserve head should be provided to overcome friction losses in piping and appurtenances through which water flows after discharge from the pump in returning to the pool, spa, or hot tub.

### K.1.3 Gauges and flow rate indicators

In all pressure filter systems serving public pools, spas, or hot tubs, a pressure gauge(s) with an appropriate range should be provided with all filters. A flow rate indicator with an appropriate range should be provided with filters for public pools, spas, or hot tubs. A flow rate controller is recommended for public pools, spas, or hot tub systems.

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<sup>30</sup> Based on atmospheric pressure at sea level.

#### **K.1.4 Location**

Filters should be readily accessible for cleaning, operation, maintenance, and servicing. Tanks should be positioned for adequate air circulation underneath and on all sides, if necessary, to reduce corrosion and permit cleaning. When filters are buried, they should be protected against corrosion and installed according to the manufacturer's recommendations.

#### **K.1.5 Multiple unit installations**

If more than one filter is needed to provide the required flow rate, filters should be installed in parallel. Each filter should provide at least 20% of the total.

### **K.2 Operation and maintenance**

For maximum performance to be obtained from a diatomite-type filter, several factors should be monitored.

#### **K.2.1 Filter aid**

The correct grade of filter aid is an important factor. Too fine a material will remove suspended particles, but will shorten the filter cycle. Too coarse a grade of filter aid will allow small particles to pass through, and with a small orifice septum, the particles may become enmeshed and be difficult to remove by normal cleaning. The grade of filter aid should be consistent with the type and size of suspended matter being removed, degree of clarity required, and length of filter run desired.

#### **K.2.2 Flow rate**

Flow rate through the diatomite-type filter determines the total output. Too high a flow rate will reduce filter runs disproportionately. The opposite is true of lower filter rates. Slurry or body feeding may permit an increase by breaking up or diluting removed particles.

#### **K.2.3 Routine cleaning**

Regular and thorough cleaning of the filter is necessary for maintenance of a pool, spa, or hot tub. This will result in labor savings, extended life of equipment, and water clarity. The following should be routine:

- a) Clean all strainers regularly, particularly before and after the pool is vacuum-cleaned and before the filter is cleaned.
- b) Lubricate the pump and motor according to the manufacturer's recommendations.
- c) Keep the pump shaft and valve stem packings in good condition.
- d) Annually inspect the filter elements and the inside of the filter tank and make any necessary repairs or adjustments.
- e) Repair leaks immediately.
- f) Protect surfaces from corrosion by painting or cleaning them regularly.

- g) Clean the filter and filter elements regularly and thoroughly, following the manufacturer's instructions.
- h) Inspect and clean the air relief system regularly.

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## Annex L<sup>31</sup>

### Sand-type filters recommendations for installation and operation

This is not a basic part of the Standard, nor the responsibility of the manufacturer.<sup>21</sup> For proper results, the following limitations should be considered in overall hydraulic design of the pool, spa, or hot tub. Sand-type filters fabricated according to this Standard will perform satisfactorily when installed and connected according to the manufacturer's recommendations. Installation and operation should comply with the applicable state and local laws and regulations.

#### L.1 Recommended installation

##### L.1.1 Turnover

Turnover will vary depending on classification of pool, spa, or hot tub bathing load and use in the following ranges:

- heavily used public pools – not more than 6 h;
- other public pools – not more than 8 h;
- residential pools – not more than 12 h;
- public spas or hot tubs – not more than 30 min; and
- residential spas or hot tubs – not more than 1 h.

##### L.1.2 Pumps

Pumps should be selected to meet design flow backwash rates under use conditions. Sufficient reserve head must be provided to overcome friction losses in piping and appurtenances through which the water flows after discharge from the pump in returning to the pool, spa, or hot tub. In installations of one to three units, pump characteristics are usually determined by design backwash requirements.

##### L.1.3 Gauges and flow rate indicators

Pressure gauges with an appropriate range should be provided on the effluent and influent lines of all filter systems. A flow rate indicator with an appropriate range should be provided for public pools, spas, or hot tubs. A flow rate controller is recommended for public pool, spa, or hot tub systems.

##### L.1.4 Location

Filters should be readily accessible for cleaning, operation, maintenance, and servicing. Tanks should be positioned for adequate air circulation underneath and on all sides, if necessary, to reduce corrosion and permit cleaning. When filters are buried, they should be protected against corrosion and installed according to the manufacturer's recommendations.

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## L.2 Operation and maintenance

For maximum performance to be obtained from a sand-type filter, several factors should be monitored.

### L.2.1 Filtration rate

The total output of sand-type filters depends on the allowable filtration rate varying from 126-1050 L/min/m<sup>2</sup> (3-25 gal/min/ft<sup>2</sup>) depending on use and design. Too high a rate may shorten filtration run; too low a rate will not give maximum use of the dirt-holding capacity of filter media, especially in high-rate filters. Optimum results may be obtained by using rates recommended by the manufacturer.

### L.2.2 Filter aids

The use of proper filter aids improves the efficiency of filtration. The manufacturer's instructions should be followed carefully to gain maximum advantage of filter aids and pool, spa, or hot tub chemicals.

### L.2.3 Routine cleaning

Regular and thorough cleaning of the filter is necessary for maintenance of a pool, spa, or hot tub. This will result in labor savings, extended life of the equipment, and water clarity. The following should be routine:

- a) Clean all strainers regularly, particularly before and after the pool is vacuum-cleaned and before the filter is cleaned.
- b) Lubricate pump and motor according to the manufacturer's recommendations.
- c) Keep the pump shaft and valve stem packings in good condition.
- d) Annually inspect the filter media and the inside of the tank and make any necessary repairs or adjustments.
- e) Repair leaks immediately.
- f) Protect surfaces from corrosion by painting or cleaning them regularly.
- g) Backwash the filter regularly and thoroughly.
- h) Inspect and clean the air relief system regularly.
- i) Properly drain equipment and appurtenances when closing down the pool, spa, or hot tub where it is subject to freezing.

## Annex M

(normative)

### Test methods for the evaluation of automated chemical controllers

#### M.1 Chemical resistance

##### M.1.1 Purpose

The purpose of this annex is to determine if the automated controller components that are normally in contact with the chemically treated water will erode or sustain structural deformation. Following chemical exposure, the accuracy of the input and output sensor signals of the controller shall be determined as specified under 17.5.1 using the applicable methods in annex M.2.

##### M.1.2 Test solutions

<b>Water temperature</b>				
<b>Swimming Pools</b>				
75° F ± 10° F (24° C ± 6° C)				
<b>Hot tubs/Spas</b>				
102° F ± 5° F (39° C ± 3° C)				
<b>Chemical Composition</b>				
	<b>Alkalinity</b>	<b>PH</b>	<b>Sanitizer</b>	
<b>1</b>	<b>80 + 15 mg/L as CaCO<sub>3</sub></b>	<b>6.8-7.4</b>	<b>Free Chlorine:</b>	<b>8-12 mg/L as Cl<sub>2</sub></b>
<b>2</b>	<b>160 +15 mg/L as CaCO<sub>3</sub></b>	<b>7.8-8.2</b>	<b>Free Chlorine:</b>	<b>8-12 mg/L as Cl<sub>2</sub></b>
NOTE 1 – All controllers, except those labeled to be for swimming pools only, shall be tested at the spa/hot tub water temperature.				
NOTE 2 – The test temperature may be obtained by heating or cooling the test water solution or by heating or cooling the ambient temperature around the automated controller equipment.				
NOTE 3 – Four separate probes/sensors are required and run in parallel for this testing.				
NOTE 4 – In order to maintain concentrations or stability of the testing chemical solutions, seal the solution container with a lid and insert probes through the lid.				

##### M.1.3 Method

- a) Expose all normally wetted parts of the probe/sensor to each of the chemical solutions in annex M, section M.1.2 for a period of 100 d ± 6 h at the ambient temperature specified in annex M, section M.1.2.
- b) Rinse the exposure solution from the probe/sensor components and operate the automated controller under normal conditions (e. g., pH 7.5, ORP 700 mV) for 24 h ± 1 h according to the manufacturer's instructions.
- c) After the 24-h period, evaluate the controller as specified under 17.5.1.

##### M.1.4 Acceptance criteria

After chemical exposure, automated chemical controller components shall show no signs of erosion or structural deformation and shall operate in accordance with 17.5.1.

## M.2 Performance

### M.2.1 Purpose

The purpose of this annex is to determine if the automated controller responds with output signals that accurately correspond with the applicable input signals under normal operating conditions.

### M.2.2 Test Water

water temperature	swimming pools	24 ± 6°C (75 ± 10°F)
	hot tubs/spas	39 ± 3°C (102 ± 5°F)

### M.2.3 Methods

Prior to performing the described methods, the automated controller shall be installed and prepared for operation according to the manufacturer's instructions. The controller shall be tested to each method with four sensors. Controllers without replaceable sensors, like colorimetric analyzers, shall have each test repeated four times.

#### M.2.3.1 pH

##### M.2.3.1.1 Monitor display accuracy

- a) Fill an appropriately sized container with the test water at the required temperature (M.2.2).
- b) Calibrate a laboratory pH meter equipped with a pH electrode according to manufacturer's instructions using appropriate buffer solutions (pH 7 and pH 10).
- c) Attach the sensor under test to the automated controller.
- d) Place the laboratory pH electrode and the sensor (attached to the automated controller), or controller influent tube into the test water solution (stir on a stir plate).
- e) Add 1 N sulfuric acid (to lower the pH) or 1 N sodium hydroxide (to raise the pH) as required to bring the test water solution pH to 7.0 as measured by the laboratory pH meter.
- f) Record the readout of the automated controller (sensor and pH meter)
- g) Add 1 N sodium hydroxide drop-wise until the laboratory pH meter reads a pH between 7.1 and 7.5. Allow the sensor and pH meter to equilibrate and record the readout of the laboratory pH meter. Record the readout of the automated controller (sensor).
- h) Repeat the previous step, this time bringing the laboratory pH meter reading to a pH between 7.5 and 8.0. Again record the readouts.
- i) Repeat the previous step again, this time bringing the laboratory pH meter reading to a pH between 8.0 and 8.2. Record the readouts.

**M.2.3.1.2 Controller output accuracy**

- a) Prepare a sample of test water listed under M.2.2 and adjust pH to 7.0 using 1 N sulfuric acid.
- b) Attach the sensor under test to the automated controller per manufacturer's instructions.
- c) Set the automated controller to a setpoint of 7.5.
- d) Attach two indicators sized for the appropriate voltage into each output terminal of the automated controller.
- e) Place the sensor under test, or controller influent tube, in the pH 7.0 solution with a total alkalinity range of 80 – 120 ppm.
- f) Record the pH level indicated on the display of the automated controller. Record the operation status of the automated controller.
- g) Slowly add 1 N sodium hydroxide solution until the controller actuates, and record the pH on the display.
- h) Slowly add 1 N sulfuric acid solution until the controller deactuates, and record the pH on the display.
- i) Repeat the test with each sensor for a total of four tests. Calculate the average pH displayed for the actuation and deactuation. Record the largest variance of a single reading from the average values.

**M.2.3.2 Chlorine/Bromine****M.2.3.2.1 Monitor display accuracy**

- a) Calibrate a spectrophotometer using standard solutions following Standard Methods 4500-Cl G, such that the instrument is capable of measuring available chlorine levels in the range of 0-10 ppm, or for bromine using HACH Method 8016 for available bromine levels in the range of 0 – 20 ppm
- b) Weigh 0.20 g of 5% sodium hypochlorite solution. Quantitatively transfer to a 1 L volumetric flask and dilute to volume using deionized water. The resulting stock solution should contain approximately 10 ppm available chlorine. For preparing an aqueous bromine solution obtain a 0.1 N Bromine Standard Solution. Perform serial dilutions (e.g. 1/10; 1/10; 1/4; 1/2) so that the resulting stock solution contains approximately 20 ppm available bromine.
- c) Using the appropriate analytical method from part a), measure the available chlorine level for the stock sodium hypochlorite solution, or the bromine level for the stock bromine standard solution.
- d) Volumetrically dilute the stock sodium hypochlorite solution by the appropriate proportions to give four solutions between 0 and 10 ppm available chlorine. For example, diluting the stock to 1/5, 1/2, and 4/5 would provide the approximate concentrations of 2 ppm, 5 ppm, and 8 ppm; these dilutions along with the stock solution would give four solutions in the required concentration range. Using the spectrophotometer, measure the available chlorine level for each sodium hypochlorite solution. For bromine volumetrically dilute the stock bromine solution by the appropriate proportions to give four solutions between 0 and 20 ppm available chlorine. For

example, diluting the 20 ppm stock to 1/10, 1/4, and 1/2, would provide the approximate concentrations of 2 ppm, 5 ppm, and 10 ppm; these dilutions along with the stock solution would give four solutions in the required concentration range. Using the analytical method referenced above, measure the available bromine level for each solution.

e) Place the sensor, or influent tube of the controller, in the mid range sample (nominal value 5 ppm for chlorine; 10 ppm for bromine). Calibrate the automated controller so that the display registers the same reading as the analytical method from step d). Place the sensor in each of the four solutions and record the readout of the sensor, by starting with the lowest concentration solution and working up to the highest concentration, rinsing the sensor between each reading.

#### **M.2.3.2.2 Controller output accuracy**

a) Using sodium hypochlorite and aqueous bromine stock solutions described in 2.3.2.1 prepare test solutions with a free available chlorine concentration of 2 mg/L as Cl<sub>2</sub> (ppm), or 4 mg/L as Br<sub>2</sub> (ppm).

b) Attach the sensor under test to the automated controller per manufacturer's instructions.

c) When testing for chlorine, set the controller to a setpoint of 3.0 ppm free available chlorine or 6.0 ppm free bromine.

d) Attach two indicators sized for the appropriate voltage into each output terminal of the automated controller.

e) Place the sensor, or influent tube, under test in the 2 ppm sodium hypochlorite solution, or the 4 ppm bromine solution.

f) Record the chlorine, or bromine level indicated on the display (in ppm) of the automated controller. Record the operation status of the automated controller.

g) Slowly add 1 N sodium hypochlorite solution (or 0.1 N aqueous bromine) until the controller deactuates. Record the chlorine or bromine ppm on the controller display.

h) Slowly add 1 N sodium thiosulphate solution until the controller actuates. Record the chlorine or bromine ppm on the controller display.

#### **M.2.3.3 ORP**

##### **M.2.3.3.1 Monitor display accuracy**

When testing the ORP probe, the alkalinity should be in the range of 80 – 120 ppm and a pH of 7.5 ± 0.2 throughout all tests. The temperature should remain constant (room temperature) throughout the duration of all of the tests ± 3° F.

a) Weigh 0.20 g of 5% sodium hypochlorite solution. Quantitatively transfer to a 1 L volumetric flask and dilute to volume using deionized water. The resulting stock solution should contain approximately 10 ppm available chlorine.

b) Volumetrically dilute the stock sodium hypochlorite solution by the appropriate proportions to give the following four solutions: 1 ppm, 3 ppm, 5 ppm, and 7 ppm chlorine.

c) Place three ORP sensors in the solution in b) and connect them to the displays/automated controllers, or place the influent tubes from three controllers in the solution, (actual samples under

test, so that there will be three independent sensor/display setups. Calibrate them per the manufacturer's instructions.

d) At each concentration record the readings of the three ORP sensors. Calculate the average of the readings at each concentration.

#### **M.2.3.3.2 Controller output accuracy**

a) Using sodium hypochlorite, prepare a test solution with a chlorine concentration of 2 mg/L as Cl<sub>2</sub> (ppm).

b) Attach the sensor under test to the automated controller per manufacturer's instructions.

c) Attach two indicators sized for the appropriate voltage into each output terminal of the automated controller.

d) Place the sensor under test, or the influent tube of the controller, in the 2 ppm sodium hypochlorite solution.

e) Set the automated controller setpoint to just activate controlled output, verify output. Reduce setpoint to just deactivate controller output, verify output. Record ORP reading at setpoint.

f) Slowly add 1 N sodium hypochlorite solution until the controller deactuates. Record the ORP display on the controller.

g) Slowly add 1 N sodium thiosulfate solution until the controller actuates. Record the ORP display on the controller.

#### **M.2.4 Life test**

Using a signal generator feed each of the sensors that directly control an output. The signal should mimic that of the sensor circuit being tested alternating between a demand for feed for a period of 1 second and off for 9 seconds. A resistive load, rated at 100% of the manufacturer's rated load, shall be connected to each of the automated controller outputs. A counter shall measure the number of cycles performed (each cycle consists of a complete on-off sequence)

#### **M.2.5 Acceptance criteria**

##### **M.2.5.1 Monitor display accuracy**

###### **M.2.5.1.1 pH**

At each of the four pH points tested, the difference between the pH level indicated on the monitor display of the automated controller and the laboratory pH meter reading shall not exceed the tolerance level given in Table 17.1. The pH on the monitor display for each actuation and deactuation shall not vary by more than +/-0.2 pH units from the average value of each set of actuation and deactuation readings.

###### **M.2.5.1.2 Chlorine/Bromine**

At each of the four available chlorine concentrations tested, the difference between the chlorine or bromine concentration indicated on the monitor display of the automated controller and the concentration measured by the appropriate analytical method used shall not exceed the tolerance level given in Table 17.1.

**M.2.5.1.3 ORP**

At each concentration none of the sensor/display combinations shall deviate by more than 10% of the average of the three readings at that setpoint.

**M.2.5.2 Controller output accuracy**

For each of the applicable parameters tested under M.2.3, the automated controller shall respond with output signals that accurately correspond with the varying input signals within the appropriate tolerance levels given in Table 17.1.

**M.2.5.3 Life test**

At the end of the test the resistive load should still be actuated on and off by the automated controller. At least one of the automated controllers should complete 110,000 cycles, and a minimum of 295,000 cycles shall be accumulated between the three automated controllers.

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## Annex N (normative)

### N.1 Test method for WQTDs

#### 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 shall be at least one increment of measure (for that test system) away from the operating range 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

Unless otherwise noted, the solutions for testing shall be at  $27^{\circ} \pm 1^{\circ}\text{C}$  ( $80^{\circ} \pm 2^{\circ}\text{F}$ ) and  $39^{\circ} \pm 1^{\circ}\text{C}$  ( $102^{\circ} \pm 2^{\circ}\text{F}$ ). If a manufacturer only claims functionality for one temperature, 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  $\text{CaCO}_3$  (Adjusted with  $\text{NaHCO}_3$ )
- Ca Hardness: 200-250 ppm  $\text{CaCO}_3$  (Adjusted with  $\text{CaCl}_2 \cdot \text{H}_2\text{O}$ )
- TDS: 1000-1500 ppm (Adjusted to this level with  $\text{NaCl}$ )
- pH: 7.4-7.6 (Adjusted with acids or bases typically used in the industry)

#### N.1.1.4 Accuracy

At each parameter tested, the average of the WQTD analyses at both temperatures shall meet the accuracy requirement in Annex N based on the level of the WQTD.

### N.1.1.5 Repeatability

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

### N.1.1.6 Reproducibility

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

## N.2 Stock Solution Preparation

- a) Sodium Bicarbonate Solution: Dissolve 16.8 g of  $\text{NaHCO}_3$  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  $\text{CaCO}_3$ , *prior to pH adjustment*.
- b) Calcium Chloride Solution: Dissolve 14.7 g  $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$  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  $\text{CaCO}_3$ .
- c) Sodium Chloride Solution: Dissolve 100 g  $\text{NaCl}$  in 500 ml DI water and dilute to one liter. Each ml added to one liter will increase TDS by 100 ppm.
- d) Chlorine Stock Solution: Dilute 1 ml of Clorox bleach to 100 ml. Determine actual Chlorine concentration by dilution and amperometric titration or DPD methods.
- e) Ammonium Chloride solution-Dissolve 0.1 g  $\text{NH}_4\text{Cl}$  in 100 ml DI water.

## N.3 pH Test

Note - Always prepare a volume of test 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. When test strips are being tested that are designed for in situ testing, a fresh aliquot must be removed from the general test water sample to immerse each test strip. Do not immerse the test strip into the general test water sample.

### N.3.1 pH Test Procedure

N.3.1.1 Determine the pH levels for the test in accordance with 17.2.

- a) Adjust the general test water pH using acids or bases typically used in the industry 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  $\pm 0.2$  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 lowest level using acid and repeat c) and d).
- f) Repeat e) for the third pH level and the fourth, if required.

**N.3.1.2** 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 acids or bases typically used in the industry to the highest level to be tested as measured by the lab meter. The pH at each level shall be maintained within  $\pm 0.2$  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 lowest 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  $\text{NaHCO}_3$  solution, 44 ml  $\text{CaCl}_2 \cdot \text{H}_2\text{O}$  solution and 14 ml NaCl solution and dilute to 2 liters. This solution will have approximately the following characteristics:

- Alkalinity-100 ppm as  $\text{CaCO}_3$
- Calcium Hardness-220 ppm as  $\text{CaCO}_3$
- TDS-1100 ppm
- pH-8.3

- a) Transfer the test 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.
- b) 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.
- c) 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.

d) Assess the results of testing based upon the resolution of the device.

#### **N.4 Test Procedure-Free Chlorine**

a) Prepare two liters of test 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 test water.

b) For each chlorine concentration to be tested (i.e. 2, 4, 5 ppm) prepare enough test solution to test the WQTD and verify the free chlorine content with either of the following:

- Spectrophotometer for use at a wavelength of 515 nm and providing a light path of 1 cm (0.4 in) or longer; or
- Filter Photometer equipped with a filter having maximum transmission in the wavelength range of 490 to 520 nm and providing a light path of 1 cm (0.4 in) or longer.

c) Record results from the above device and WQTD.

d) Assess the results of testing based upon the resolution 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.

a) Combined chlorine is tested at one concentration level.

b) To test combined chlorine, add approximately 100 ml of test 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.

c) 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 (or equivalent method) results and the WQTD result.

d) Assess the results of testing based upon the resolution of the device.

## N.6 Accuracy Testing

### N.6.1 Accuracy levels for pH

#### Range of operation 5 to 10

L1	Between 5.0 and 6.2	+/- 0.2 pH
	Between 6.2 and 7.2	+/- 0.2 pH
	Between 7.2 and 7.8	+/- 0.2 pH
	Between 7.8 and 8.4	+/- 0.2 pH
	Between 8.4 and 10.0	+/- 0.2 pH
L2	Between 5.0 and 6.2	+/- 0.4 pH
	Between 6.2 and 7.2	+/- 0.2 pH
	Between 7.2 and 7.8	+/- 0.2 pH
	Between 7.8 and 8.4	+/- 0.2 pH
	Between 8.4 and 10.0	+/- 0.4 pH
L3	Between 5.0 and 6.2	+/- 1.0 pH
	Between 6.2 and 7.2	+/- 0.5 pH
	Between 7.2 and 7.8	+/- 0.5 pH
	Between 7.8 and 8.4	+/- 0.5 pH
	Between 8.4 and 10.0	+/- 1.0 pH
	Strip or comparator	Within 1 increment of the expected value

### N.6.2 Accuracy levels for Chlorine; free and combined

#### Range of operation 0 to 10 ppm

L1	Between 0 and 10	+/- 0.1
L2	Between 0 and 1	+/- 0.25
	Between 1 and 3	+/- 0.5
	Between 3 and 5	+/- 1.0
	Between 5 and 10	+/- 2.5
L3	Between 0 and 1	+/- 0.25
	Between 1 and 3	+/- 0.5
	Between 3 and 5	+/- 1.0
	Between 5 and 10	+/- 2.5
	Strip or comparator	Within 1 increment of the expected value

**N.6.3 Accuracy levels for Bromine total, and free****Range of operation 0 to 10 ppm**

L1	Between 0 and 10	+/- 0.2
L2	Between 0 and 3	+/- 0.5
	Between 3 and 6	+/- 1.0
	Between 6 and 10	+/- 2.0
L3	Between 0 and 6	+/- 1.0
	Between 6 and 10	+/- 2.0
	Strip or comparator	Within 1 increment of the expected value

**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  $23\text{ }^{\circ}\text{C} \pm 4\text{ }^{\circ}\text{C}$  ( $73\text{ }^{\circ}\text{F} \pm 8\text{ }^{\circ}\text{F}$ ) 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.

## Standards<sup>32</sup>

The following standards established and adopted by NSF as minimum voluntary consensus standards are used internationally:

- 2 Food equipment
- 3 Commercial warewashing equipment
- 4 Commercial cooking, rethermalization, and powered hot food holding and transport equipment
- 5 Water heaters, hot water supply boilers, and heat recovery equipment
- 6 Dispensing freezers
- 7 Commercial refrigerators and freezers
- 8 Commercial powered food preparation equipment
- 12 Automatic ice making equipment
- 13 Refuse processors and processing systems
- 14 Plastics piping system components and related materials
- 18 Manual food and beverage dispensing equipment
- 20 Commercial bulk milk dispensing equipment
- 21 Thermoplastic refuse containers
- 24 Plumbing system components for recreational vehicles
- 25 Vending machines for food and beverages
- 29 Detergent and chemical feeders for commercial spray-type dishwashing machines
- 35 High pressure decorative laminates (HPDL) for surfacing food service equipment
- 36 Dinnerware
- 37 Air curtains for entrances in food and food service establishments
- 40 Residential wastewater treatment systems
- 41 Non-liquid saturated treatment systems
- 42 Drinking water treatment units – Aesthetic effects
- 44 Residential cation exchange water softeners
- 46 Evaluation of components and devices used in wastewater treatment systems
- 49 Biosafety cabinetry: Design, construction, performance and field certification
- 50 Equipment for swimming pools, spas, hot tubs and other recreational water facilities
- 51 Food equipment materials
- 52 Supplemental flooring
- 53 Drinking water treatment units – Health effects
- 55 Ultraviolet microbiological water treatment systems
- 58 Reverse osmosis drinking water treatment systems
- 59 Mobile food carts
- 60 Drinking water treatment chemicals – Health effects
- 61 Drinking water system components – Health effects
- 62 Drinking water distillation systems
- 143 Environmentally preferable products – Hard surface cleaners
- 169 Special purpose food equipment and devices
- 170 Glossary of food equipment terminology
- 173 Dietary supplements
- 177 Shower filtration systems – Aesthetic effects
- 184 Residential dishwashers
- 222 Ozone generators
- 245 Wastewater treatment systems – Nitrogen reduction
- 305 Personal care products containing organic ingredients
- 330 Glossary of drinking water treatment unit terminology
- 14159-1 Hygiene requirements for the design of meat and poultry processing equipment
- 14159-2 Hygiene requirements for the design of hand held tools used in meat and poultry processing equipment
- 14159-3 Hygiene requirements for the design of mechanical belt conveyors used in meat and poultry processing equipment

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