RWF Task Group on Filters
Straw Ballot
August 26, 2021

Purpose

This straw ballot will revise language relating to filter testing.

Background

There are 4 outstanding issue papers pertaining to Regenerative Media Precoat Filter (RMF) technology with the oldest dating back to August 2008. While it is commonly known and has been demonstrated to the RWF JC through pictures of clear RMF filters in operation, many of the filters currently certified have bridging of media between the individual elements. NSF/ ANSI Standard 50 under section 5.2.1.3 precludes surface contact or bridging between the filter elements. This has been overlooked during certification testing of RMF filters due to superior performance in turbidity reduction. To add further complication the RMF filters are typically designed in a densely packed tubular element configuration with small viewing windows to observe filter media behavior in a localized area. Many if not all NSF certified RMF filters are operating using a bump cycle to dislodge filter media at timed intervals and recoating the filter element assembly with this already used filter media. While this has been a critical function within the operation of these filters – NSF/ ANSI Standard 50 doesn't have language or testing protocol to address the design and use of this function. This has resulted in 100's if not 1000's of these filters being installed and operated using a bump function that was not validated during testing and certification of the filter design. There have been previous attempts to address the outlined issues and with no consensus agreement reached within the RWF ad hoc for RMF filters. In 2011 an issue paper was presented to RWF JC to allow for incidental bridging of RMF filters and it failed to pass ballot at the 2012 RWF JC meeting. At the 2016 RWF JC meeting, the RWF Task Group on Filters was tasked with making the necessary revisions to Standard 50 to change to a performance-based filter test.

The RWF ad hoc on performance-based testing met multiple times to draft language, and eventually sent r1 language to straw ballot. That ballot received multiple comments, and an r2 ballot was straw balloted with the Task Group on Filters, which drew additional comments. This r3 language addresses those comments.

This straw ballot will last two weeks.

The grey highlighted portions of the language are proposed additions to the language of the standard.
The ~~strikeout~~ portions of the language are proposed deletions to the language of the standard.

An affirmative (yes) vote on this straw ballot means you agree with the revised language as submitted.

A negative (no) vote on this straw ballot means you disagree with the revised language as submitted. A negative vote must include an explanation of why you disagree with the revised draft.

[Note – the recommended changes to the standard which include the current text of the relevant section(s) indicate deletions by use of ~~strikeout~~ and additions by grey highlighting. Rationale Statements are in *italics* and only used to add clarity; these statements will NOT be in the finished publication.]

NSF/ANSI Standard

Equipment and Chemicals 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

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6 Filters

6.1 General

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

Precoat media-type filters will considered regenerative when there is a designed pause in operation where the filter aid is released from the element(s) with a repositioning of this filter aid into a new filter cake to extend the length of the filter run. Precoat filters that operate intermittently at set times during a day without replacing the filter cake shall not be considered regenerative media filters.

Any claims of enhanced filter performance such as but not limited to finer filtration or water savings shall require validation of claims during performance testing. The additional testing protocol for validation of these claims shall be agreed upon by the filter manufacture and testing agency before starting any performance testing. The pass/ fail criteria shall be based on confirmation of the enhanced performance claims being repeatably met.

6.1.1 Filter tanks (pressure service)

6.1.1.1 The working pressure of a pressure service filter shall be 50 psi (345 kPa) 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).

6.1.1.2 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 Section N-2.1:

— 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 N-2, 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 *ASME Boiler and Pressure Vessel Code*,**Error! Bookmark not defined.** Section VIII or X, shall be exempt from this requirement.

6.1.2 Filter tanks (vacuum service)

6.1.2.1 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).

6.1.2.2 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 25 in Hg (85 kPa) for 300 s in accordance with Section N-2.2.

6.1.3 Internal components

6.1.3.1 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 N-2.

6.1.3.2 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 N-2.

6.1.3.3 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.

6.1.4 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 Section N-2.3.

Precoat media-type filters that regenerate the precoat media filter cake shall be tested in accordance with Section N-2.3 after the media has been conditioned as described in 6.1.9.1. Manufacturers of regenerative precoat filters may specify separate head loss claims for media that is at the beginning and end of the regeneration life or may specify one head loss curve that is not exceeded by the observed head loss when the precoat media is new or at the end of the media life.

6.1.5 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.

6.1.6 Drains

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

6.1.7 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.

6.1.8 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. For precoat type filters, this shall be checked by a visual inspection of the internals of the filter after soiling per Annex N-2, Section N-2.4 and cleaning in accordance with the manufacturer's instructions, but prior to reintroduction of any filtration media. Inspection may be carried out via disassembly of the filter housing or another suitable means agreed upon by the filter manufacturer and laboratory.

Residual precoat media between adjacent elements near the mounting surface of the elements shall have an average depth not exceeding 5% of the total length of the element, rounded up to the nearest ¼", that extends beyond the mounting surface support plate.

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 Section N-2.4.

6.1.9 Turbidity reduction

A filter shall reduce water turbidity by 70% or more when tested in accordance with Section N-2.5.

Precoat media-type filters that regenerate the precoat media filter cake shall be tested for conformance with the turbidity reduction requirements of Section N-2.5 with new precoat and again after the media has been conditioned as described in 6.1.9.1.

Precoat media-type filters that operate internittently without replacing the filter cake shall have 5 periods of no operational flow with each pause lasting a minimum of 10 minutes, ± ½ minute, before performing the turbidity reduction testing outlined in Section N-2.5.

6.1.9.1 Regenerative media conditioning

Start with a new application of precoat media and start to recirculate clean water (< 2 NTU) through the filter. Initiate injection into the inlet piping of the filter a solution of ball clay and baby oil, in a relative proportion conforming with Section N-2.4.3.1, to achieve a filter influent turbidity of 10±10 NTU, until the pressure drop of the filter increases by 50%, or if the manufacturer recommends a maximum pressure drop, inject the solution of ball clay and baby oil until the pressure drop increases by 50% or the until the maximum pressure drop recommended by the manufacturer is achieved, whichever is less. Stop injection of the ball clay and baby oil and regenerate the precoat media in accordance with the manufacturer's instructions. Repeat this soiling/regeneration process until one of the criteria below has been achieved:

— For regenerative filters which determine the end of life of a charge of media based on time, repeat once for each day of the lifespan of a charge indicated by the manufacturer's instructions; or

— For regenerative filters which determine the end of life of a charge of media based on the number of regenerations, repeat a number of times equal to the number of regenerations permitted by the manufacturer's instructions; or

— For regenerative filters which determine the end of life of a charge of media based on the pressure conditions observed after regeneration, repeat until the pressure conditions observed after regeneration meet the manufacturer's recommended conditions for replacing the media; or

— If the lifespan of a charge of media is defined by the manufacturer's instructions using a combination of the criteria detailed above, repeat until the first criteria indicated by the manufacturer's instruction has been achieved.

6.1.10 *Cryptosporidium parvum* oocyst reduction

6.1.10.1 A filter manufacturer may make a *C. parvum* log reduction claim up to a maximum of 1.0 log. A filter claimed by the manufacturer to reduce *C. parvum* shall be tested in accordance with Section N-2.9. The verified *C. parvum* log reduction determined in accordance with Section N-2.9 shall be noted on the data plate.

6.1.10.2 Polystyrene latex microspheres, as referenced in the test method for bag and cartridge filter systems in NSF/ANSI 419: *Public Drinking Water Equipment Performance – Filtration*, shall be an acceptable surrogate for live *C. parvum* oocyst.

6.1.10.3 The polystyrene latex microspheres shall have 95% of particles in the range of 3.00 ± 0.15 µm. The size variation of the polystyrene microspheres shall be confirmed by electron microscopy. The spheres shall have a surface charge content of less than 2 µeq/g. The microspheres shall contain a fluorescein isothiocyanate (FITC) dye or equivalent.

6.1.10.4 The maximum feed concentration shall be 10,000/L, to prevent overseeding that will lead to artificially high log removals performance.

6.1.10.5 Detection and enumeration of polystyrene microspheres shall be done in accordance with Annex A of NSF/ANSI 419.

6.1.10.6 If a filter has been validated for a reduction of *C. parvum* in accordance with Section 6.1.10 and Section N-2.9, the installation and operating instructions shall contain the following information:

— the validated log reduction, shall be indicated via the following statement:

> *"This filter has demonstrated the ability to provide a 1.0 log reduction of Cryptosporidium parvum at a flow rate of XXX gpm when tested with 3-µm polystyrene microspheres."*

— cleaning instructions, including but not limited to any backwash, rinse, filter to drain, or auxiliary recirculation steps. Minimum and maximum flow rates and times shall be included for each step;

— remediation instructions specific to the handling of waste, rinse, and/or backwash water that may contain *C. parvum.* These instructions must include a statement that all waste, rinse and backwash water generated by this filter must be directed to a sanitary sewer; and

— the allowable range of pressure drop through the filter, what pressure drop, or flow reduction indicates cleaning is required, and the terminal pressure drop requiring changeout of the media

6.1.10.7 If a filter has been validated for a reduction of *C. parvum* in accordance with Section 6.1.9.2 and Section N-2.9, the data plate shall contain the following information:

— the validated log reduction shall be indicated on the data plate via the following statement:

> *"This filter has demonstrated the ability to provide a 1.0 log reduction of Cryptosporidium parvum when tested with 3-µm polystyrene microspheres."*

— name and grade of media used during the validation testing of *C. parvum* reduction and a statement that use of any other media invalidates the *C. parvum* reduction claim of the filter; and

— the data plate shall also include the following statement:

> *"Follow the cleaning and remediation instructions provided in the operating manual for safe handling of filter cleaning and wastewater. All waste, rinse, and/or backwash water generated by this filter must be directed to a sanitary sewer."*

6.2 Precoat media-type filters

The requirements in this subsection apply only to precoat media-type filters utilizing diatomite or other precoat filter media (that conforms to Section 13) and their integral components designed for the filtration of swimming pool or spa / hot tub water.

6.2.1 Filtration area

6.2.1.1 Non-flexible type

~~**6.2.1.1**~~ The actual filtration area shall be within ± 5% of the effective filtration area specified on the filter data plate.

6.2.1.1.1 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 0.25 in (6.4 mm) in contact with the septum during filtration.

6.2.1.1.2 For non-flexible tube-type precoat media-type filters, the effective filtration area is equal to the total surface area of the precoat filter ~~media-coated~~ uncoated tubes minus the combined area of all septum support members wider than 0.25 in (6.4 mm) 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.~~

~~**6.2.1.2** For wire wound and similar-type elements, the width of septum support members shall not exceed 0.25 in (6.4 mm). The distance between adjacent septum members and the distance between adjacent openings shall not exceed 0.005 in (0.127 mm).~~

~~**6.2.1.3** Septa shall be maintained in such a position as to preclude surface contacts that reduce effective filtration area.~~

6.2.2 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 Section N-2.6, except 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.

~~6.2.3 Spacing of elements~~

~~**6.2.3.1** Filters shall be designed to provide a minimum clearance between adjacent filter elements equal to the thickness or diameter of the element or 1 in (25 mm), whichever is less.~~

~~**6.2.3.2** The clearance between filter elements shall be sufficient to prevent contact between the septa during backwashing operations.~~

~~6.2.4 Baffles~~

6.2.3 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.

6.2.~~5~~4 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.

6.2.~~6~~5 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.~~

The manufacturer shall provide a manual with each filter. The manual shall contain the following information:

— operating instructions;

— cleaning instructions;

— installation instructions;

— design head loss curve;

— parts lists;

— any drawings or charts necessary to permit proper installation, operation, and maintenance of the filter;

— recommended amount, type, and grade of filter aid; and

— recommended lifespan for a charge of media.

6.2.~~7~~6 Data plate

6.2.~~7~~6.1 A precoat media-type 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 contact information (address, phone number, website, or prime supplier);

— filter model number;

— filter serial number;

— effective filtration area in square meters or square feet;

— if applicable, the statement “This precoat filter utilizes tube elements and the effective filtration area represents the uncoated area”;

— required clearance (vertical and horizontal for service and maintenance);

— design flow rate in LPM or GPM;

— 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.

6.2.~~7~~6.2 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).

6.2.~~8~~7 Filtration rate

The design filtration rate of precoat media-type filters shall not exceed the values specified in Table 6.1.

Table 6.1
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	3 gal/min/ft^2 (122 L/min/m^2)
slurry feed	public pool or spa / hot tub	2.5 gal/min/ft^2 (102 L/min/m^2)
no slurry feed	residential pool or spa / hot tub	2.5 gal/min/ft^2 (102 L/min/m^2)
tube type	residential / public	3 gal/min/ft^2 (122 L/min/m^2) based on uncoated surface area
no slurry feed	public pool or spa / hot tub	2 gal/min/ft^2 (81 L/min/m^2)

6.2.~~9~~8 Precoat filter media

Precoat media shall conform to the requirements of Section 4, Materials.

6.2.~~9~~8.1 Precoat media other than diatomaceous earth (DE)

Precoat media other than DE shall also conform to the requirements of Sections N-2.3 through N-2.7.

6.2.~~9~~8.2 Precoat media labeling requirements

Precoat media shall contain the following information on the product packaging or documentation shipped with the product:

— manufacturer’s name and contact information (address, phone number, website, or prime supplier);
— product identification (product type and trade name);
— net weight or net volume;
— when applicable, mesh or sieve size;
— lot number or other production identifier such as a date code;
— when appropriate, special handling, storage and use instructions; and

— the specific certification mark of the certifying organization for certified products.

6.3 Sand-type filters

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.

6.3.1 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.

6.3.2 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.

6.3.3 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 0.189 in (4.8 mm) wide are exempt from this requirement.

6.3.4 Filter media

6.3.4.1 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 0.016 in (0.40 mm) and 0.022 in (0.55 mm), 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.

6.3.4.2 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 Section N-2.4.

6.3.4.3 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 Sections 4.2, 6.1.8, 6.1.9, 6.3.4.3, and 5.3.5 when tested in a representative sand-type filter in accordance with Sections N-2.3 through N-2.5.

6.3.4.3.1 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[Error! Bookmark not defined.] with sieves conforming to ASTM E11.[Error! Bookmark not defined.]

6.3.4.3.2 The filtration rate and backwash rate for an alternate sand-type media shall be as specified in Section 6.3.9.

6.3.4.3.3 Sand-type media labeling requirements

Sand-type media shall contain the following information on the product packaging or documentation shipped with the product:

- — manufacturer's name and contact information (address, phone number, website, or prime supplier);
- — product identification (product type and trade name);
- — net weight or net volume;
- — when applicable, mesh or sieve size;
- — lot number or other production identifier such as a date code;
- — when appropriate, special handling, storage and use instructions; and
- — the specific certification mark of the certifying organization for certified products.

6.3.5 Filter media behavior

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

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

6.3.5.3 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 6.2.

Table 6.2
Maximum difference in media surface elevations on a sand type filter

Filter diameter (D)[1]	Maximum elevation difference
< 36 in (0.9 m)	3 in (76 mm)
36 to 63 in (0.9 to 1.6 m)	0.083 × D
> 63 in (1.6 m)	5.25 in (135 mm)
[1] For filters with noncircular surface geometry, D shall equal the maximum horizontal dimension on the media surface.	

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

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

6.3.6 Installation and operating instructions

6.3.6.1 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.

6.3.6.2 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.

6.3.7 Data plate

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

— manufacturer's name and contact information (address, phone number, website, or prime supplier);
— filter model number;
— filter serial number or date code;
— effective filtration area in square meters or square feet;
— required clearance (vertical and horizontal for service and maintenance);
— design flow rate in LPM or GPM;
— design backwash flow rate in LPM or GPM;
— working pressure, or design collapse pressure for vacuum filter tanks;
— suitability for buried installation;
— steps of operation;
— filtration rate in gal/min/ft^2 or L/min/m^2; and
— special media specifications, if any, as required in Section 6.3.4.1.

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.

6.3.7.2 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).

6.3.8 Effective filtration area

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

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 0.25 in (6.4 mm) passing through the surface of the filter media bed.

6.3.9 Filtration and backwash rates

6.3.9.1 The design filtration rate of sand-type filters shall conform to the limits specified in Table 6.3.

Table 6.3
Design filtration rates for sand type filters

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

6.3.9.2 The design backwash rate shall be a minimum of 15 gal/min/ft^2 (610 L/min/m^2).

6.4 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.

6.4.1 Clearance

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

6.4.2 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.

6.4.3 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.

6.4.4 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.

6.4.5 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.

6.4.6 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.

6.4.7 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.

6.4.8 Data plate

6.4.8.1 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 contact information (address, phone number, website, or prime supplier);

— 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 LPM or GPM;
— 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.

6.4.8.2 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).

6.4.9 Filtration area

The actual filtration area shall be within ± 5% of the effective filtration area specified on the filter data plate. 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 0.25 in (6.4 mm) in direct contact with the cartridge / element material during filtration.

6.4.10 Filtration rates

The design filtration rate of a cartridge-type filter shall not exceed the maximum values specified in Table 6.4.

Table 6.4
Maximum design filtration rates for cartridge-type filters

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

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

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Normative Annex 2
(formerly Annex B)

Test methods for the evaluation of filters

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

N-2.1 Hydrostatic pressure test (pressure service filters)

N-2.1.1 Purpose

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

N-2.1.2 Apparatus

— a pressure testing rig capable of delivering and regulating hydrostatic pressure on a filter tank;

— temperature-indicating device (required accuracy: ± 2 °F [± 1 °C]);

— timer (required accuracy: ± 0.5 s); and

— pressure gauges sized to yield the measurement within 25% to 75% of full scale (required accuracy: ± 2% of reading or ± 1 psi [7 kPA], whichever is greater).

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.

N-2.1.3 Challenge water

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

N-2.1.4 Hydrostatic pressure test method (pressure service filters)

a) Install filter media or elements, or both, 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 ± 30 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 30 ± 1 psi (207 ± 7 kPa) and maintain it for 2 ± 0.5 s. The pressurization rate shall not exceed 30 psi/s. Slowly release the pressure and maintain a hydrostatic pressure of 0 psi (0 kPa) for 2 ± 0.5 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.

N-2.1.5 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 Section N-2.1.4.e shall not constitute a failure.

N-2.2 Vacuum test (vacuum service filters)

N-2.2.1 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.

N-2.2.2 Apparatus

— vacuum source capable of creating a vacuum on a filter tank as required by this test;

— temperature-indicating device (required accuracy is ± 2 °F [± 1 °C]);

— timer (required accuracy is ± 0.5 s); and

— vacuum gauges sized to yield the measurement within 25% to 75% of full scale (required accuracy is ± 2% of reading or ± 1 psi [7 kPa], 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.

N-2.2.3 Challenge water

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

N-2.2.4 Vacuum test method (vacuum service filters)

a) Install filter media or elements, or both, 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 25 ± 1 in Hg (85 ± 3.4 kPa) to the filter tank. Maintain the vacuum for 300 ± 30 s. Slowly release the vacuum and examine the tank for evidence of a rupture, collapse, leak, or other deformation.

N-2.2.5 Acceptance criteria

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

N-2.3 Head loss test

N-2.3.1 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.

N-2.3.2 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 ± 2 °F [± 1 °C]);

— flow meter (required accuracy is ± 1 GPM (± 4 LPM) 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;

— pressure measurement taps sized to the filter's inlet and outlet; and

— for testing the initial head loss of an alternate sand-type media, the media shall be installed in a 24 in (624 mm) diameter sand-type filter for which the head loss with sand is known.

N-2.3.3 Challenge water

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

N-2.3.4 Method

a) Install a pressure measurement tap at the filter inlet and the filter outlet. The taps shall 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 shall 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 ± 30 s. See special instructions in Section N-2.3.4.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:

$$HLF = (P_1 - P_2) + [Z_1 \times (9.81)\ W] / 1{,}000 - HLP$$

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

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 (lb/ft^3)
Z_1 = height of inlet centerline above outlet centerline (ft)
HLP = head loss due to piping from P_1 to P_2 (ft)

NOTE — conversions:

HLF (m) × 9.81 = *HLF* (kPa)
HLF (ft) × 0.4335 = *HLF* (psi)
P (psi) × 2.307 = *P* (ft)

or

where:

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

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 Section 6.3.5.3.

N-2.3.5 Acceptance criteria

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

N-2.4 Filter media cleanability test

N-2.4.1 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.

N-2.4.2 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 ± 2 °F [± 1 °C]);

— flow meter (required accuracy is ± 1 GPM (± 4 LPM) 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 (624 mm) diameter sand-type filter that has previously passed the cleanability test with sand.

Regenerative precoat media filters shall be supplied with a means to remove the assembled filter elements and support structure or other agreed upon means to allow for inspection of filter aid retention between the elements and mounting plate.

N-2.4.3 Challenge slurries

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

N-2.4.3.1 Swimming pool / spa / hot tub filter applications

Tap water with 0.04 ± 0.01 lb of ball clay,[1] 189 mg baby oil,[2] and 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 (4.8 ± 1 g of ball clay, 50 mg of baby oil, and 4.8 ± 1 g of diatomaceous earth added for every liter per minute). No diatomaceous earth is added to the challenge slurry when testing a diatomite-type filter.

N-2.4.4 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 15 psi (103 kPa), whichever is greater.

d) 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

[1] A possible resource for ball clay: OM-4 (old Mine 4), Rovin Ceramics, 253 Dino Drive, Suite A, Ann Arbor, MI 48103. <rovinceramics.com>

[2] A possible resource for baby oil: Johnson's Baby Oil,® Johnson & Johnson, Inc., 1 Johnson & Johnson Plaza, New Brunswick, NJ 08933. <www.jnj.com>

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 Section 6.3.

e) Clean the unit per the manufacturer's instructions. Examine the filter media, elements, or cartridges for soil, organics, and filter aid.
f) Operate the unit in accordance with the test method in Section N-2.3.4 and determine the head loss at the design flow rate.

N-2.4.5 Acceptance criteria

The filter media or non-regenerative precoat elements shall be visibly free of soil, organics, and filter aid. Regenerative media precoat elements shall be visibly free of soil and organics with any residual precoat media between adjacent elements near the mounting surface of the elements not exceeding an average 5% depth of the total length of the element, rounded up to the nearest ¼", that extends beyond the mounting surface support plate.

The head loss through the filter after cleaning or replacing the filter aid shall not exceed 150% of the initial head loss through the filter as determined in accordance with Section N-2.3.

N-2.5 Turbidity reduction test

N-2.5.1 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.

N-2.5.2 Apparatus

— flow meter (required accuracy is ± 1 GPM [± 4 LPM] 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 ± 2 °F [± 1 °C]);

— silica #140;[3]

— water tank and pump system capable of delivering water at the design flow rate through the filter;

— pressure measurement taps sized to the filter's inlet and outlet; and

— for testing the turbidity reduction of an alternate sand-type media, the media shall be installed in a 24 in (624 mm) diameter filter with a maximum bed depth of 10 in (254 mm). A tank with 630 gal (2,385 L) 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 (624 mm), the media approval shall be limited to the test filter size or larger.

[3] A possible resource for silica: Sil-co-Sil 106, US Silica, 24275 Katy Freeway, Suite 600, Katy, TX 77494. <wwwussilica.com>

N-2.5.3 Challenge water

	Swimming pool / spa / hot tub filters
water temperature	75 ± 10 °F (24 ± 6 °C)
turbidity prior to adding silica	≤ 2 NTU
turbidity after adding silica #140	45 ± 5 NTU

N-2.5.4 Turbidity reduction test method

a) Determine the volume of water needed to achieve a turnover time according to the equation below when the filter is operated at the maximum design flow rate. Fill the test tank with the required volume of water.

$$\text{turnover time (minutes)} = \left(\frac{8}{\sqrt{U}} + 8\right), \pm 5\%, \text{ maximum } 30$$

where:

$$U = \text{filtration rate, } \left(\frac{\text{gpm}}{\text{ft}^2}\right) = \frac{\text{maximum design flow rate (gpm)}}{\text{effective filtration area } \left(\text{ft}^2\right)}$$

Volume (gallons) = turnover time (minutes) × maximum design flow rate (gpm)

If the prescribed turnover time requires a test volume greater than 10,000 gallons, the turnover time may be shortened to limit the test volume to 10,000 gallons.

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 ± 5 NTU.

c) Install and condition the filter according to the manufacturer’s instructions. Operate the filter at the maximum 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:

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

f) If the filter reaches the manufacturers recommended condition for cleaning prior to completing five tank turnovers, draw a sample from the filter effluent at the time the filter reaches the manufacturer’s recommended condition for cleaning, and measure the turbidity (*TB3*).

g) High capacity cartridge filters only (as defined in Section 2): if the TR ratio is > 0.30 after five tank turnover times has elapsed and the filter has not reached the manufacturer’s recommended condition for cleaning, a second turbidity reduction test may be performed, steps (a) through (f), without cleaning the filter. Prior to this second test, the water from the test tank and the filter housing shall be drained.

The water used for the second test shall meet the requirements of Section N-2.5.3. The acceptance criteria shall be applied to the TR ratio from this second test.

N-2.5.5 Acceptance criteria

After the fifth tank volume, the *TR* ratio shall be ≤ 0.30. This is equivalent to a 70% or greater reduction in turbidity.

Filters that reach the manufacturer's recommended condition for cleaning prior to completing five turnovers, shall have TR ratio ≤ 0.30 at the time the filter reaches the manufacturer's recommended condition for cleaning.

N-2.6 Precoat media-type filters – Turbidity limits, precoat operation

N-2.6.1 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.

N-2.6.2 Apparatus

— flow meter (required accuracy is ± 1 GPM [± 4 LPM] 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 ± 2 °F [± 1 °C]);

— 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.

N-2.6.3 Challenge water

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

N-2.6.4 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 2 GPM/ft^2 (84 LPM/m^2).

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.

N-2.6.5 Acceptance criteria

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

N-2.7 Cellulose media longevity test

N-2.7.1 Purpose

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

N-2.7.2 Apparatus and test method

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

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 N-2, Table N-2.1.

d) Charge the filter with the DE grade specified by the manufacturer.

e) Set the flow rate to 2 gal/min/ft^2 (81 L/min/m^2) of filter area.

f) When the water clears, record the pressure drop.

g) Run the test continuously while administering the doses in Section N-2.7.3 until the pressure drop increases by 10 psi (70 kPa) or the flow rate drops by 10 GPM (40 LPM).

h) Duplicate the test setup with the cellulose media.

Table N-2.1
Challenge water

pH	Turbidity	Free chlorine

7.5 ± 0.5	< 1	1 to 2 ppm

N-2.7.3 Dosing

a) Prepare a ball clay mixture by mixing 2.80 lb (1270 gm) ball clay 0.10 lb (45 gm) of baby oil and 7.99 lb (3625 gm) of water.

b) Dose a 0.12 lb (55 gm) 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.

N-2.7.4 Acceptance criteria

The cellulose media shall last at least as long as DE before a recharge is needed. The turbidity level measured in Section N-2.7.3 shall not exceed 1 NTU throughout the duration of the test.

N-2.8 Media permeability and cake density test procedure

N-2.8.1 Purpose

The purpose of this test is to determine the cake density and D'Arcy permeability of precoat type filtration media.

N-2.8.2 Equipment

— scale, accurate to ± 0.01 gm;
— vacuum gauge, accurate to ±1% FS;
— stopwatch, capable of measuring 0.01 s;
— thermocouple, accurate to ± 1 °F (± 0.5 °C);
— permeability testing rig (see Figure 2);
— 1-in diameter 8-S filter paper;
— 100-mL glass beaker;
— 100-mL graduated cylinder; and
— rinse bottle with deionized water.

N-2.8.3 Procedure

a) Three 2.00 ± 0.05 g samples of the filtration media shall be measured and recorded.

b) A new filter shall be installed under the permeability tube.

c) The valve on the permeability rig shall be closed and the vacuum shall be adjusted to 20.0 ± 0.1 Hg.

d) A clean glass beaker shall be filled with 30 ± 1 mL of deionized water. The temperature of the water shall be measured and recorded.

e) One of the 2.00-g samples of filtration media shall be placed in the beaker to make slurry.

f) The slurry shall be added to the permeability tube. The valve shall be opened at the base of the tube as the slurry is added.

g) The slurry shall be removed from the beaker by rinsing with a wash bottle filled with deionized water. Approximately 2 to 3 rinses shall be required.

h) The cake shall be allowed to build by allowing the water to run down to a level approximately 1 mL above the cake.

i) The permeability tube shall be refilled with clean deionized water above the 24 mL graduation.

j) A timer shall be started as the water level reaches and passes the 24 mL graduation. As the water level passes the 16 mL graduation, the timer shall be stopped. Record the time to flow 8 mL.

k) The water shall be allowed to flow out of the tube and past the cake. The valve shall be closed at the bottom of the permeability rig.

l) The volume of the cake shall be measured and recorded to 0.1 mL.

m) The permeability tube shall be removed and cleaned.

n) Steps b through m shall be repeated two additional times.

o) D'Arcy Permeability shall be calculated using the following equation:

$$\text{D'Arcy Permeability} = K = (q * \mu * \Delta X) / (A * \Delta P)$$

where:

K = D'Arcy Permeability, cm^2
q = fluid flow rate, mL/s
μ = dynamic viscosity, Pa*s
ΔX = thickness of the medium, cm
A = cross-sectional area of the medium, cm^2
ΔP = applied pressure differential, Pa

p) Cake density shall be calculated using the following equation:

$$\text{cake density (lb/ft}^3\text{)} = 62.428 * \text{sample mass (g)} / \text{cake volume (mL)}$$

N-2.8.4 Acceptance criteria

The initial and annual testing results of average cake density and average D'Arcy permeability shall be within ± 10% for density and ± 20% for permeability of the manufacturer's claim.

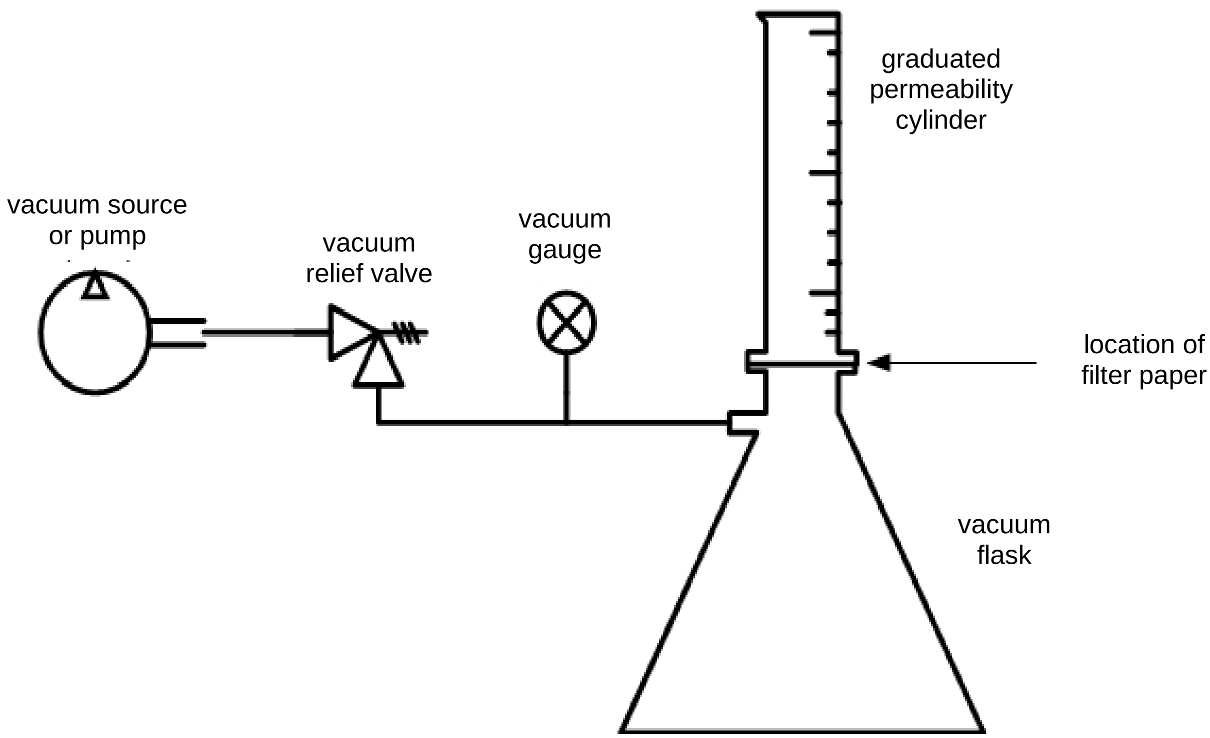

Figure 2
Permeability test set-up

N-2.9 Test method for *Cryptosporidium parvum* oocyst reduction

N-2.9.1 Cartridge and bag type filters

Cartridge and Bag Filters shall be evaluated according to NSF/ANSI 419: *Public Drinking Water Equipment Performance – Filtration* (Section 5).

As specified in Section C.3.2 of NSF/ANSI 419, the log reduction value assigned to a filter shall be the minimum value obtained from all test conditions.

The manufacturer of the filter may claim a 1.0 log reduction of *C. parvum*; the claim shall not exceed the minimum observed $LRV_{condition}$.

N-2.9.2 Precoat media type filters

N-2.9.2.1 Apparatus

— flow meter (required accuracy is ± 1 GPM [± 4 LPM] or ± 3% of reading, whichever is greater);

— pressure-recording device (required accuracy is ± 0.5 psi 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 ± 2 °F [± 1 °C]);

— water tank and pump system capable of delivering water at the design flow rate through the filter;

— pressure measurement taps sized to the filter's inlet and outlet; and

— polystyrene latex microspheres

N-2.9.2.2 Challenge water

pH	7.2 to 7.6
alkalinity	≥ 20 mg/L as $CaCO_3$
hardness	200 to 400 mg/L as $CaCO_3$
temperature	50 to 81°F
turbidity	≤ 0.3 NTU
total / free available chlorine	0 ppm
iron	≤ 0.3 mg/L
manganese	≤ 0.3 mg/L

N-2.9.2.3 Test dust

Test dust is used to load the filter to create a pressure drop across the filter. Test dust shall be added to the general test water as specified in the following procedure to achieve a maximum turbidity of 10 NTU. The test dust shall be ISO 12103-1 A3 Medium Arizona Test Dust.

N-2.9.2.4 Procedure

a) Fill a test tank and condition to water parameters specified above.

b) Static mixers shall be installed three pipe diameters upstream of the filter influent and effluent collection taps. Influent and effluent sample taps shall extend into the center of the piping.

c) Install precoat media and condition the filter according to the manufacturer's instructions.

d) Begin filter operation at the manufacturer's maximum claimed flow rate. The filter effluent shall be recirculated to the test tank.

e) A negative control sample shall be collected from the influent and effluent sample taps and analyzed for microspheres.

f) Begin injection of the challenge microsphere suspension to obtain a maximum feed concentration of 10,000/L. Influent and effluent samples shall be collected after three void volumes of water containing the challenge have passed through the test filter. Test sample taps shall be flushed before each sample collection.

g) After sample collection is complete, challenge suspension injection shall be stopped, and filter operation shall continue.

h) Begin injection of the test dust and operate the filter until the pressure drop across the filter reaches 50 ± 5% of the backwash pressure differential as specified by manufacturer. The water in the tank shall then be recirculated without test dust or microsphere additions until the tank turbidity has dropped to ≤ 2 NTU.

i) Ensure that the pressure drop across the filter is still 50 ± 5% of the backwash pressure differential as specified by manufacturer and begin injection of the microsphere suspension to obtain a maximum feed concentration of 10,000/L and collect influent and effluent samples after three void volumes of water containing the challenge have passed through the test filter. Test sample taps shall be flushed before each sample collection.

j) After sample collection is complete, challenge suspension injection shall be stopped, and filter operation shall continue.

k) Begin injection of the test dust and operate the filter until the pressure drop across the filter reaches 100 ± 5% of the backwash pressure differential as specified by manufacturer. The water in the tank shall then be recirculated without test dust or microsphere additions until the tank turbidity has dropped to ≤ 2 NTU.

l) Ensure that the pressure drop across the filter is still 100 ± 5% of the backwash pressure differential as specified by manufacturer and begin injection of the microsphere suspension to obtain a maximum feed concentration of 10,000/L and collect influent and effluent samples after three void volumes of water containing the challenge have passed through the test filter. Test sample taps shall be flushed before each sample collection.

m) After sample collection is complete, challenge suspension injection shall be stopped, and filter shall be cleaned in accordance with the manufacturer's instructions.

n) After cleaning, install precoat media and condition the filter according to the manufacturer's instructions.

o) Restart filtration and injection of the microsphere suspension to obtain a maximum feed concentration of 10,000/L and collect influent and effluent samples immediately after restarting the flow, after one, two and three void volumes of water containing the challenge have passed through the test filter, and after 5 min of operation. Test sample taps shall be flushed before each sample collection. As the test is being performed with recirculation of filtration effluent, measured feed concentrations of up to 5.0×10^4 shall be considered as conforming to the method. However, for the purpose of calculating observed log reductions values, the influent concentration shall be capped at 1.0×10^4.

N-2.9.2.5 Analytical methods

Detection and enumeration of microspheres in each sample shall be analyzed in triplicate and in accordance with Annex A of NSF/ANSI 419.

N-2.9.2.6 Acceptance criteria

The geometric means of the triplicate analyses of the microsphere test samples shall be log transformed to calculate the log removal value of each of the conditions tested, $LRV_{condition}$:

— initial startup of filter;
— 50 ± 5% of pressure differential;
— 90 ± 5% of pressure differential;
— immediately after cleaning;
— 1 void volume after cleaning;
— 2 void volumes after cleaning;
— 3 void volumes after cleaning; and
— 5 min of operation after cleaning.

The manufacturer of the filter may claim a 1.0 log reduction of *C. parvum* not exceeding the minimum observed $LRV_{condition}$.

N-2.9.3 Sand type filters

N-2.9.3.1 Apparatus

— flow meter (required accuracy is ± 1 GPM [± 4 LPM] or ± 3% of reading, whichever is greater);

— pressure-recording device (required accuracy is ± 0.5 psi 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 ± 2 °F [± 1 °C]);

— water tank and pump system capable of delivering water at the design flow rate through the filter;

— pressure measurement taps sized to the filter's inlet and outlet; and

— polystyrene latex microspheres.

N-2.9.3.2 Challenge water

pH	7.2 to 7.6
alkalinity	≥ 20 mg/L as $CaCO_3$
hardness	200 to 400 mg/L as $CaCO_3$
temperature	50 to 81°F
turbidity	≤ 0.3 NTU
total / free available chlorine	0 ppm
iron	≤ 0.3 mg/L
manganese	≤ 0.3 mg/L

N-2.9.3.3 Test dust

Test dust is used to load the filter to create a pressure drop across the filter. Test dust shall be added to the general test water as specified in the following procedure to achieve a maximum turbidity of 10 NTU. The test dust shall be ISO 12103-1 A3 Medium Arizona Test Dust.

N-2.9.3.4 Procedure

a) Fill a test tank and condition to water parameters specified above.

b) Static mixers shall be installed three pipe diameters upstream of the filter influent and effluent collection taps. Influent and effluent sample taps shall extend into the center of the piping.

c) Install media and condition the filter according to the manufacturer’s instructions, including any backwash and filter to drain operations specified.

d) Begin filter operation at the manufacturer’s maximum claimed flow rate. The filter effluent shall be recirculated to the test tank.

e) A negative control sample shall be collected from the influent and effluent sample taps and analyzed for microspheres.

f) Begin injection of the challenge microsphere suspension to obtain a maximum feed concentration of 10,000/L. Influent and effluent samples shall be collected after three void volumes of water containing the challenge have passed through the test filter. Test sample taps shall be flushed before each sample collection.

g) After sample collection is complete, challenge suspension injection shall be stopped, and filter operation shall continue.

h) Begin injection of the test dust and operate the filter until the pressure drop across the filter reaches 50 ± 5% of the backwash pressure differential as specified by manufacturer. The water in the tank shall then be recirculated without test dust or microsphere additions until the tank turbidity has dropped to ≤ 2 NTU.

i) Ensure that the pressure drop across the filter is still 50 ± 5% of the backwash pressure differential as specified by manufacturer and begin injection of the microsphere suspension to obtain a maximum feed concentration of 10,000/L and collect influent and effluent samples after three void volumes of water containing the challenge have passed through the test filter. Test sample taps shall be flushed before each sample collection.

j) After sample collection is complete, challenge suspension injection shall be stopped, and filter operation shall continue

k) Begin injection of the test dust and operate the filter until the pressure drop across the filter reaches 100 ± 5% of the backwash pressure differential as specified by manufacturer. The water in the tank shall then be recirculated without test dust or microsphere additions until the tank turbidity has dropped to ≤ 2 NTU.

l) Ensure that the pressure drop across the filter is still 100 ± 5% of the backwash pressure differential as specified by manufacturer and begin injection of the microsphere suspension to obtain a maximum feed concentration of 10,000/L and collect influent and effluent samples after three void volumes of water containing the challenge have passed through the test filter. Test sample taps shall be flushed before each sample collection.

m) After sample collection is complete, challenge suspension injection shall be stopped, and filter shall be cleaned in accordance with the manufacturer's instructions.

n) After cleaning, restart filtration and injection of the microsphere suspension to obtain a maximum feed concentration of 10,000/L and collect influent and effluent samples immediately after restarting the flow, after one, two and three void volumes of water containing the challenge have passed through the test filter, and after 5 minutes of operation. Test sample taps shall be flushed before each sample collection. As the test is being performed with recirculation of filtration effluent, measured feed concentrations of up to 5.0×10^4 shall be considered as conforming to the method. However, for the purpose of calculating observed log reductions values, the influent concentration shall be capped at 1.0×10^4.

N-2.9.3.5 Analytical methods

Detection and enumeration of microspheres in each sample shall be analyzed in triplicate and in accordance with Annex A of NSF/ANSI 419.

N-2.9.3.6 Acceptance criteria

The geometric means of the triplicate analyses of the microsphere test samples shall be log transformed to calculate the log removal value of each of the conditions tested, $LRV_{condition}$:

— initial startup of filter;
— 50 ± 5% of pressure differential;
— 90 ± 5% of pressure differential;
— immediately after cleaning;
— 1 void volume after cleaning;
— 2 void volumes after cleaning;
— 3 void volumes after cleaning; and
— 5 min of operation after cleaning.

The manufacturer of the filter may claim a 1.0 log reduction of *C. parvum*; the claim shall not exceed the minimum observed $LRV_{condition}$.