Designation: D7601 – 10

Standard Practice for Pressure Driven Membrane Separation Element/Bundle Evaluation[1]

This standard is issued under the fixed designation D7601; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice covers the inspection, performance testing, autopsy and analytical work associated with evaluating pressure driven membrane separation elements (MF, UF, NF and RO).

1.2 This practice is applicable for elements when newly manufactured or at any time during their operation in a water treatment facility. The Analytical section covers only membrane surface and foulant analyses.

1.3 The data derived from these tests should be evaluated versus newly manufactured elements/bundles or against operating systems when they were initially brought on-stream, or both. Industry norms can also be used for comparative purposes.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D1129 Terminology Relating to Water

D3923 Practices for Detecting Leaks in Reverse Osmosis and Nanofiltration Devices

D4194 Test Methods for Operating Characteristics of Reverse Osmosis and Nanofiltration Devices

D4472 Guide for Recordkeeping for Reverse Osmosis and Nanofiltration Systems

D4516 Practice for Standardizing Reverse Osmosis Performance Data

D5090 Practice for Standardizing Ultrafiltration Permeate Flow Performance Data

D6161 Terminology Used for Microfiltration, Ultrafiltration, Nanofiltration and Reverse Osmosis Membrane Processes

D6908 Practice for Integrity Testing of Water Filtration Membrane Systems

D7285 Guide for Recordkeeping Microfiltration and Ultrafiltration Systems

3. Terminology

3.1 For definitions of terms used in this practice, refer to Terminology D1129 and Terminology D6161.

4. Summary of Practice

4.1 This practice discusses the inspection of the pressure driven membrane separation elements required for individual units to be readied for a visual inspection or an autopsy that can be performed to ascertain structural integrity (Practice D6908) and cleanliness. Visual inspection is non-destructive testing; autopsy requires the dismantlement of the element.

4.2 Performance testing of an element are discussed that can be accomplished on or off line, in a single or multi-element housing under conditions proscribed by the user or element manufacturer or Test Methods D4194. The data collected (Guides D4472 and D7285) must then be normalized (Practices D4516 and D5090) to a set of conditions that permit the element's performance to be compared to an as-new unit.

4.3 Laboratory analyses are presented that include visual, usually non-destructive, as well as specialized instrumentation, usually destructive testing.

5. Significance and Use

5.1 Water treatment membrane devices can be used to produce potable water from brackish supplies and seawater as well as to upgrade the quality of industrial water. This standard permits the evaluation of the integrity and performance of membrane elements using visual observations and standard sets of conditions and are for short-term testing (< 24 h). This standard can be used to determine changes that may have occurred in the operating characteristics of elements but are not intended to be used for plant design.

[1] This practice is under the jurisdiction of ASTM Committee D19 on Water and is the direct responsibility of Subcommittee D19.08 on Membranes and Ion Exchange Materials.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

6. Tests

6.1 *Physical Inspection:*

6.1.1 *Spiral Wound Elements:*

6.1.1.1 Disconnect element housing from the operating system and remove element to be inspected from housing, placing it on a work table.

6.1.1.2 Examine the element for cracked or dislodged, or both, end caps, telescoping, discolored scrolls, fiberglass discoloration and cracks, contaminants on fiberglass surface and in product tube, and any other abnormalities.

6.1.1.3 Weigh element and compare to the nominal as-new unit weight supplied by the manufacturer.

6.1.1.4 Record findings.

6.1.1.5 If element is to be reinserted into operating system or other flow tests are to be performed at a later time, visual testing should not be too long as to dry out the element.

6.1.2 *Hollow Fiber Elements:*

6.1.2.1 *Visual Inspection:*

(1) Disconnect element from the operating system, placing it on a work table.

(2) Examine the element for cracked nub or tube sheet, or both, telescoping, outer wrapping discoloration and cracks, contaminants on outer wrapping surface and in feed tube, and any other abnormalities.

(3) Weigh element and compare to the nominal as-new unit weight supplied by the manufacturer.

(4) Record findings.

(5) If element is to be reinserted into operating system or other flow tests are to be performed at a later time, visual testing should not be too long as to dry out the element, thereby, adversely affecting the membrane continuity..

6.1.2.2 *Rod Test (when it is proper):*

(1) The rod test is used to detect a collapse or obstructed feed tube, brine tube or distributor. For this test, a simple rod that is at least the length of the bundle(s) and has a diameter slightly smaller than the tube(s) to be tested is employed. The test can be accomplished without dismantling the bundle.

(2) Remove the plugs or connections, isolating the tube to be tested.

(3) Insert the rod into the tube to the maximum penetration possible.

(4) An unobstructed tube will allow full penetration. An obstructed tube will not allow full penetration indicating damage. Repair, if possible, will require disassembly of the element/housing.

6.2 *Performance:*

6.2.1 *Probing of Spiral Wound Elements:*

6.2.1.1 Test is performed for identifying which spiral element in a multi-element housing is defective. It is performed on a system that is operating by assessing radical changes in conductivity from one end of the element to the other. The location of the flaws further back from the permeate tube can be obscured by the permeate mixing before the permeate reaches the tube.

6.2.1.2 A typical probe design is seen in Figs. 1 and 2 and can also be obtained from element manufacturer.

6.2.1.3 Product conductivity data collection should be obtained every 2 to 6 in.

6.2.1.4 Look for abnormal or discontinuous changes in conductivity.

6.2.1.5 Assess integrity of membrane and glue lines from this information.

6.2.2 *Wet-Test (Refer to Test Methods D4194 and Guides D4472 and D7285):*

6.2.2.1 Disconnect element housing from operating system and remove element to be inspected from housing, placing it on a work table.

6.2.2.2 Insert element into single unit housing and appropriately connect the utility lines.

6.2.2.3 Wet test element at standard conditions for the element. Test conditions can be determined by using the membrane manufacturer's product data sheets. The as-new performance (flow, rejection, differential pressure drop) of element can also be obtained from the membrane manufacturer's product data sheets.

6.2.2.4 If it is impractical to follow exactly the standard conditions specified by the membrane manufacturer, other operating conditions can be employed. The data is then normalized to standard conditions using the equations given in Practices D4516 and D5090 so that a comparison to as-new performance can be made.

6.2.3 *Integrity and Leak Testing:*

6.2.3.1 Integrity and leak testing of elements at frequent intervals are very important so that systems can conform to governmental regulations.

6.2.3.2 Procedures for these tests are given in Practices D3923 and Practice D6908.

6.3 *Autopsy*—Autopsy is performed when all the non-destructive tests have been carried out and the cause for element or system mal-performance has not been fully determined. When autopsy is undertaken on an individual element, this unit can no longer be employed to assess operating characteristics.

6.3.1 *Spiral Wound Elements:*

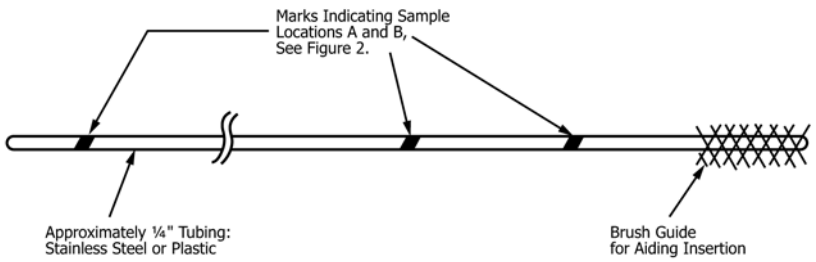

FIG. 1 Product Sampling Probe

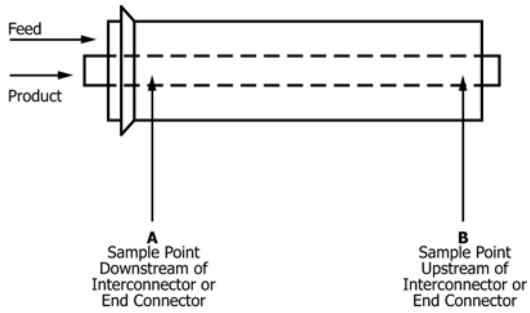

FIG. 2 Cartridge Sampling Locations

6.3.1.1 Disconnect element housing from the operating system and remove element to be inspected from housing, placing it on a work table or floor if more room is needed.

6.3.1.2 Cut-off the end caps.

6.3.1.3 Remove the element outer covering so that the element internals are fully exposed.

6.3.1.4 Count the number of leaves.

6.3.1.5 Visual inspections.

(1) Element fabrication.

(a) Determine the integrity of the glue lines.

(b) Look for folded leaves or broken fibers.

(c) Examine glue line adhesion.

(2) Feed spacer.

(a) Observe if foulants are present that may be blocking fluid flow. Take samples for later analysis if present.

(b) Look for extrusion or any signs of telescoping.

(3) Membrane.

(a) Is the surface slimy, oily or gritty.

(b) Look for membrane imperfections such as wrinkles, creases scratches, holes.

(c) Measure the effective membrane area on several sheets.

(d) Take a number of membrane samples, randomly, from different leaves and over the length of the element for later analysis.

(e) Keep membrane samples wet. If storing the samples for any long period, add a disinfectant.

(4) Record everything that seems unusual during these inspections.

6.3.2 *Hollow Fiber Elements:*

6.3.2.1 Disconnect element housing from the operating system, placing it on a work table or floor if more room is needed.

6.3.2.2 Cut-off the nub and tube sheet epoxy.

6.3.2.3 Remove the outer covering so that the bundle internals are fully exposed.

6.3.2.4 Unroll the element and measure its length.

6.3.2.5 Visual inspections.

(1) Element fabrication.

(a) Determine if any discoloration is present on the fibers.

(b) Assess physical strength of fiber/rope by testing the physical strength and elongation of these fibers versus virgin material.

(2) Spacer.

(a) Observe if foulants are present that may be blocking fluid flow. Take samples for later analysis if present.

(b) Look for extrusion or any signs of telescoping.

(3) Membrane.

(a) Is the surface slimy, oily or gritty.

(b) Look for membrane imperfections such as creases scratches, holes.

(c) Take a number of membrane samples from different areas over the length of the bundle for later analysis.

(d) Keep membrane samples wet. If long term storage, add a disinfectant.

(4) Record everything that seems unusual during these inspections.

6.4 *Analytical*—There are many laboratory analytical tests that can be performed on samples. The most typical ones are given below.

6.4.1 *Spiral Wound Elements:*

6.4.1.1 *Continuous Monitoring Particulate Light Scattering Methods*—Monitors product water for membrane integrity (Practice D6908).

6.4.1.2 *Electron Spectroscopy (ESCA)*—Determines chemical analysis of foulants.

6.4.1.3 *Epifluorescent Microscopy*—Determining bacteria count on membrane.

6.4.1.4 *350 to 1000 Optical Microscopy*—Enlarges picture of surface foulants.

6.4.1.5 *Fourier Transform Infrared (FTIR) Spectroscopy*—Identifies organics and inorganics and changes in polyamide structures.

6.4.1.6 *Fujiwara Dye*—Looks for halogenation or oxidation, or both, of a composite polyamide RO/NF membrane.

6.4.1.7 *Loss on Ignition (LOI)*—Looks at amount of foulant that is organic.

6.4.1.8 *Plasma Emission Spectroscopy (ICP)*—Analyzes metals on membrane surface.

6.4.1.9 *Pressure Decay*—Determines membrane integrity (Practice D6908).

6.4.1.10 *Protein and Carbohydrate Content*—Analyzes biomass.

6.4.1.11 *Scanning Electron Microscopy (SEM)*—Determines foulant elemental composition.

6.4.1.12 *Soluble Dye*—Checks integrity of membrane (Practice D6908).

6.4.1.13 *Targeted Dispersive X-Ray (T-EDAXA)*—Takes picture of inorganic foulants on membrane surface.

6.4.1.14 *Total Organic Analyzer*—Monitors integrity of reverse osmosis and nanofiltration systems (Practice D6908).

6.4.1.15 *Vacuum Decay*—Determines membrane integrity (Practice D6908).

6.4.1.16 *X-Ray Diffraction (XRD)*—Characterizes crystallographic structure of material.

6.4.2 *Hollow Fiber Elements:*

6.4.2.1 *Continuous Monitoring Particulate Light Scattering Methods*—Monitors product water for membrane integrity (Practice D6908).

6.4.2.2 *Electron Spectroscopy (ESCA)*—Determines chemical analysis of foulants.

6.4.2.3 *Epifluorescent Microscopy*—Determining bacteria count on membrane.

6.4.2.4 *350 to 1000 Optical Microscopy*—Enlarges picture of surface foulants.

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6.4.2.7 *Plasma Emission Spectroscopy (ICP)*—Analyzes metals on membrane surface.

6.4.2.8 *Pressure Decay*—Determines membrane integrity (Practice D6908).

6.4.2.9 *Protein and Carbohydrate Content*—Analyzes biomass.

6.4.2.10 *Rodding*—When proper, determines that the element's internal tubes are open and clear of debris.

6.4.2.11 *Scanning Electron Microscopy (SEM)*—Determines foulant elemental composition.

6.4.2.12 *Soluble Dye*—Checks integrity of membrane (Practice D6908).

6.4.2.13 *Targeted Dispersive X-Ray (T-EDAXA)*—Takes picture of inorganic foulants on membrane surface.

6.4.2.14 *Total Organic Analyzer*—Monitors integrity of reverse osmosis and nanofiltration systems (Practice D6908).

6.4.2.15 *Vacuum Decay*—Determines membrane integrity (Practice D6908).

6.4.2.16 *X-Ray Diffraction (XRD)*—Characterizes crystallographic structure of material.

7. Keywords

7.1 element evaluation; microfiltration; nanofiltration; reverse osmosis; ultrafiltration