GUIDANCE FOR USE OF ALTERNATIVE FILTRATION TECHNOLOGIES

PURPOSE

This document is intended as a guide for public water systems (PWS) requesting approval for the use of an alternative filtration technology (AFT) as defined in Hawaii Administrative Rules (HAR) Title 11, Chapter 20. AFT is defined as a filtration technology other than conventional filtration, direct filtration, diatomaceous earth filtration, or slow sand filtration for the treatment of surface water (including seawater), and groundwater under the direct influence of surface water (GWUDI). Applicable filtration technologies may include but are not limited to: microfiltration (MF), ultrafiltration (UF), nanofiltration (NF), reverse osmosis (RO), cartridge filtration, and bag filtration.

AUTHORSHIP

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OVERVIEW

This document provides guidance on the approval and implementation of PWSs employing AFTs for surface water and GWUDI sources. This includes required and recommended procedures and guidance during initial AFT approval, preliminary and plant design, and start-up and operations. The document provides guidance in the following areas:

1. Challenge Testing
2. Source Water Monitoring
3. Pilot Testing
4. Backwash Water Recycle
5. Engineering Report
6. Plans and Specifications
7. Start-up Testing
8. Integrity Testing
9. Reporting

GUIDANCE

1. Challenge Testing

AFTs shall be Challenge Tested before they are approved for use in surface water or GWUDI treatment plants. Challenge testing is a performance test that allows DOH to determine the appropriate removal credits granted for pathogens, including *Giardia*, *Cryptosporidium*, and viruses. This testing is product specific for each cartridge/bag filter element or membrane module. Challenge testing shall be completed for individual elements or modules but is not required for the full AFT unit. An AFT unit is defined as a group of elements or modules sharing common valving that can be operated independently or isolated from the rest of the treatment system.

Alternative filtration systems that have been previously Challenge Tested do not need to be retested for new installations or sites, provided that the cartridge/bag filter element or membrane module is identical to one that has been previously tested and approved by DOH. Challenge Test Reports developed for certifications done in other states may be submitted for approval by DOH, provided the testing requirements comply with the guidance described herein, and that both the full testing report and approval letter from the associated state are submitted to DOH for review.

a. Requirements for Challenge Testing

Challenge Testing for cartridge filters, bag filters, MF, and UF shall be performed by a third party that is independent of the AFT's manufacturer. The testing protocol must be in accordance with the US Environmental Protection Agency's (USEPA) *Membrane Filtration Guidance Manual*, published in November 2005. Challenge Testing for RO and NF membranes may be performed by the AFT manufacturer, provided that standard testing procedures described in this guidance document are followed.

Challenge Tests performed under NSF International/ANSI Standard 419 *Public Drinking Water Equipment Performance – Filtration* (NSF 419) are acceptable for all AFTs. Equivalent testing performed by other third-party agencies or the USEPA Environmental Technology Verification (ETV) program may also be accepted at the State's discretion.

b. Challenge Testing for Spiral Wound NF/RO Membranes

As an alternative to the NSF 419 testing protocol, challenge testing for spiral wound RO and NF membranes may be performed in accordance with ASTM D4194-03 *Standard Test Methods for Operating Characteristics of Reverse Osmosis and Nanofiltration Devices*, using a specified salt solution as a pathogen surrogate. A PWS or AFT manufacturer choosing to use this testing for approval of RO and NF membranes must provide documentation of the testing protocol and resulting salt rejection for the proposed RO or NF membrane. The testing conditions to determine salt rejection shall be as follows:

1) Testing protocol must comply with ASTM D4194-03.
2) NF/RO units must be tested using solutions of magnesium chloride ($MgCl_2$), calcium chloride ($CaCl_2$), or sodium chloride (NaCl).
3) Feed concentrations and pressures are dependent on the type of membrane tested and must be reported to DOH in the submitted documentation.
4) The pH of the feed water must be kept at 7.5 ± 0.5 standard units.

5) Permeate temperature shall be 25° C ± 1° C throughout the test.

6) Reported values must be within 20-30 minutes of test startup.

For the proposed NF/RO system, the PWS or AFT manufacturer must submit a print out of the manufacturer's computer model using water quality from the intended source water. This requirement is independent of challenge testing and must be submitted for all cases when an NF/RO system is to be used. Pathogen credits granted will be based on the lowest of:

- The log reduction of the target salt demonstrated during challenge testing;
- The log reduction of the selected marker measured online for direct integrity testing (e.g. TDS, TOC, or silica);
- The log reduction of the selected marker projected by the manufacturer's computer model for the proposed water quality and operating conditions over a five-year membrane life; or
- The maximum log reduction credit identified for RO/NF membranes in Table 1.

c. Removal Credits

Removal credits will be assigned by DOH, based on the results of the challenge testing and the demonstrated sensitivity of proposed integrity testing methods. Maximum credits granted for each category of AFT and each pathogen type are listed in Table 1. In all cases, a minimum of 4.0-log inactivation of viruses must be achieved using disinfection, regardless of the filtration credit granted.

Table 1: Maximum Pathogen Removal Credits for Alternative Filtration Technologies

Technology	Log Removal Credit			Notes
	Giardia	***Cryptosporidium***	**Virus**	
Cartridge/ Bag Filter (Individual)	2.0	2.0	0	Feed water turbidity must be less than 1.5 NTU to use cartridge or bag filters (2) Must achieve 1.0-log factor of safety
Cartridge/ Bag Filters (In Series)	2.5	2.5	0	Feed water turbidity must be less than 1.5 NTU to use cartridge or bag filters (2) Must achieve 0.5-log factor of safety
MF/UF	4.0	4.0	1.0	Assumes hollow fiber membrane with pressure/vacuum decay direct integrity test
NF/RO	2.0 (1)	2.0 (1)	2.0 (1)	For spiral wound membrane with approved marker-based integrity test with demonstrated removal exceeding requested pathogen credit

(1) DOH may approve an LRV higher than 2.0-log for RO or NF where challenge testing and marker performance are shown to consistently demonstrate greater than 3.0-log reduction.

(2) If source water cannot meet this requirement, pre-treatment will be required.

2. Source Water Monitoring

In accordance with HAR 11-20, Section 29 *Use of new sources of raw water for public water systems*, all new sources of drinking water shall be monitored for all regulated and unregulated contaminants in drinking water. Refer to *Contaminants to be Tested in All New Sources of Drinking Water* for requirements.

a. Additional Monitoring for Systems Using AFTs

Additional source water sampling is required for surface water and GWUDI sources where AFTs will be utilized. Sampling must be done over a minimum of 14 consecutive days, incorporating wet weather conditions. Daily rain gage readings from contributing watershed areas and, if applicable, daily stream or ditch flow data must be reported along with the water quality data for the following parameters:

- Total Organic Carbon, including dissolved fraction (grab sample 3 times per week);
- Formation potential for both Total Trihalomethanes (TTHM) and 5 Haloacetic Acids (HAA5) (grab sample 3 times per week); and
- Turbidity, as measured by a continuous monitoring and recording instrument. A copy of the chart shall be provided to SDWB.

In addition, a PWS intending to utilize RO or NF membranes for desalination must monitor parameters related to membrane fouling and membrane performance with a minimum of two samples for each parameter identified in Table 2. Testing results must be included with the Engineering Report.

Table 2: Additional Raw Water Quality Parameters for RO and NF Supplies

Cations	Anions	Other
Aluminum	Chloride	Alkalinity
Barium	Fluoride	pH
Calcium	Nitrate	Silt Density Index (SDI)
Iron	Phosphate	TDS
Magnesium	Silica	TOC
Manganese	Sulfate	Turbidity
Potassium		Temperature
Sodium		
Strontium		

3. Pilot Testing

Generally, site specific pilot testing of an AFT is not required for approval of the AFT or for its use in a PWS. However, site specific pilot testing is encouraged to confirm design criteria and recommend operating conditions for the full-scale facility. Pilot testing should be conducted during a period that represents seasonal worst-case conditions (e.g. rainy season). Pilot testing involves three major components: test protocol, pilot operation, and a final report.

a. Test Protocol

Test protocol for the pilot study should be submitted to DOH for review before piloting takes place. The report should outline:

- Existing source water quality data;
- Analytes to be treated;
- Rationale for treatment process selection;
- Schedule for pilot study;
- Location of proposed pilot plant and full-scale plant;
- Proposed water quality goals for all streams, including primary and secondary contaminants in raw and product water streams;
- Product and waste water disposal;
- Diagrams and explanations of the proposed pilot and full-scale treatment trains, including:
  - Treatment processes;
  - Location of sampling points;
  - Chemicals and their injection points;
  - Type, location, and calibration frequency of instrumentation;
  - Information on pre-treatment (coagulation, prefiltration, etc.) and post-treatment (corrosion control) goals;
- Water quality sampling matrix and schedule, including:
  - Water quality parameters;
  - Sample frequency and location; and
  - Specify on-site analysis or State-certified laboratory.

Pilot testing should include the minimum water quality data identified in Table 3, sampled on both the raw and filtered side of the treatment train during the steady-state portion of the pilot testing process.

Table 3 - Recommended Sampling Parameters and Frequency for Pilot Tests

Sampling Parameter	Cartridge Filters/ Bag Filters	Microfiltration/ Ultrafiltration	Reverse Osmosis/ Nanofiltration
Turbidity	Continuous	Continuous	Daily
Conductivity	Grab once/week	Grab once/week	Continuous
TOC	Grab 2 days/week	Grab 2 days/week	Grab once/month
Formation potential for TTHM & HAA5	Grab once/week	Grab once/week	Grab once/month
Microscopic particulate analysis (MPA) to 2 μm	Grab in 2nd week	Grab in 2nd week	Grab in 2nd week
Total and fecal coliforms	Grab 4 days/week	Grab 4 days/week	GWUDI: Grab 4 days/week; All others: Grab once/week
Parameters observed in source water above 80% of MCL or secondary MCL	Grab once/week	Grab once/week	Grab once/week

In addition to the parameters listed in Table 3, other parameters related to membrane fouling and performance, including parameters identified previously in Table 2, should be monitored at frequencies commensurate with the anticipated risk of impact on membrane performance.

b. Testing Operation

SDWB recommends pilot testing for a minimum of 90 days, based on the following breakdown of operation:

- 30 days of optimization;
- 30 days under optimized, steady-state design (no major adjustments); and
- 30 days after first clean-in-place (CIP) after the 30 days under optimized design.

Any discharge of product and waste during pilot testing shall comply with all applicable state and federal standards.

c. Final Report

When pilot testing is completed, a final pilot study report shall be submitted to DOH containing the following (at a minimum):

- The seal, signature, and date of a Professional Engineer registered in the State of Hawaii;
- A restatement of the water quality goals;
- A written discussion of the pilot test and problems encountered during piloting;
- Design recommendations for the full-scale plant;
- Water quality results, including full lab reports with QA/QC data;
- Instrumentation logs during steady state and post-CIP operation; and
- A list of all on-site tests conducted, test methods used, test equipment calibration methods and frequencies (including flowmeters), and the results of each calibration test and any necessary adjustments to the test equipment.

4. Backwash Water Recycle for MF/UF Systems

Membrane filters, including MF and UF, are periodically backwashed to remove contaminants from the membrane modules. A PWS choosing to recycle all or a portion of this backwash water may do so using one of two alternative approaches:

- Option 1: Recycle backwash water to the plant headworks; or
- Option 2: Install two-stage membrane system

This guidance does not apply to cartridge filters, RO membranes, or NF membranes that do not employ backwashing.

a. Recycle backwash water to the plant headworks

Recycled backwash water may be returned to the headworks of the treatment plant or to a different location with DOH approval. In all cases, backwash water returned from an MF or UF system must undergo settling or other equivalent clarification process (e.g. dissolved air flotation) prior to the water being reintroduced to the membranes. This settling may be done as part of the primary treatment train or on the backwash water prior to recycling.

Systems intending to recycle backwash water shall submit a technical memorandum to DOH for review and approval. Recycling of backwash water shall not proceed without DOH approval. The technical memorandum shall include:

- A formal, written notification of the system's intent to recycle backwash water;
- Design flow for the treatment plant (gpm);
- State-approved plant operating capacity;
- Highest observed plant flow experienced in the previous year (gpm);
- Plant schematic showing:
  - Location where recycled backwash flow is introduced back into the treatment plant;
  - Origin of all recycled backwash flows and the frequency with which they are returned;
  - Hydraulic conveyance used to transport recycled backwash flow.
- A description of the treatment provided for the recycled flow with specific information on:
  - Typical recycle flow (gpm);
  - Average and maximum backwash flow rate through the filters (gpm);
  - Average and maximum duration of the filter backwash process in minutes;
  - Typical filter run length and written summary of how filter run length is determined;
  - Data on the physical dimensions of the equalization units and/or treatment units;
  - Typical and maximum hydraulic loading rates;
  - Types of chemicals used, average dose, and frequency of use;
  - Frequency at which solids are removed; and
  - Control logic, including alarms and interlocks, that will be utilized to regulate the backwash recycle flow.

During operation, the system shall collect and retain all the above information on file.

b. <u>Install two-stage membrane system</u>

A PWS utilizing a second stage membrane system to recover backwash water from a primary system must calculate a plant-wide log reduction value (LRV) using the methodology described below. In this arrangement, after the water is filtered through a primary filtration stage, the primary stage backwash waste (typically 5 to 10 percent of the overall flow) is equalized and filtered through a second stage of membranes. A typical schematic is shown in Figure 1:

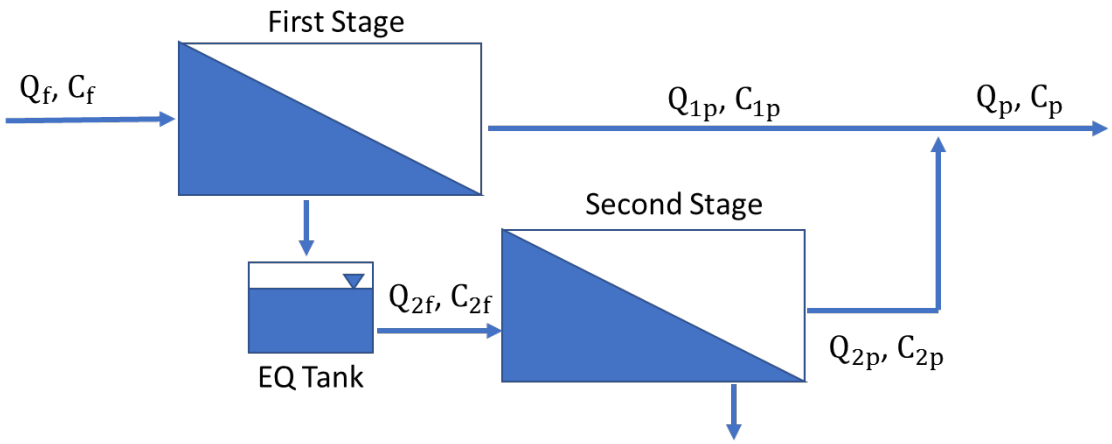

Figure 1: Two-Stage Membrane Filtration Schematic

Where Q_f, Q_{2f}, Q_p, Q_{1p}, and Q_{2p} represent flow rates and C_f, C_{2f}, C_p, C_{1p}, and C_{2p} represent microbial pathogen concentrations.

Systems proposing to use this option must follow the same procedures for technical memorandum preparation and DOH notification as described previously for Option 1. In addition, the technical memorandum for Option 2 must include full specifications of the membrane equipment used in the secondary system, including locations of flow and indirect integrity monitoring.

The overall system LRV must be calculated using the LRV achieved by the individual membrane units and a mass balance between the primary and secondary system flows. Where multiple units or skids are used in a stage, the lowest LRV calculated for any of the units in each stage must be used. LRV for each unit must be calculated daily, based on direct integrity testing results, with a plant wide total LRV calculated daily. The anticipated plant wide LRV must be calculated and presented in the Engineering Report, based on the LRV granted for each membrane system and the anticipated maximum flow rates.

The following calculation should be used for calculating the plant wide LRV, based on the flows identified in Figure 1. Where multiple units or skids are used, the daily maximum value for the sum of flows for all units shall be used.

$$LRV_{total} = -log\left(\frac{Q_f}{Q_p}(10^{-LRV_1} + 10^{-LRV_2})\right)$$

Below is an example calculation for a plant with an 800 gpm average production flow and operating with a net recovery of 98 percent (90% recovery first stage, 80% recovery second stage). Note that because maximum instantaneous flows are used in these calculations, both Q_f and Q_p exceed the 800 gpm average production, and Q_p may exceed Q_f.

Q_f = 820 gpm
Q_p = 902 gpm
LRV_1 = 4.0-log
LRV_2 = 4.0-log

$$LRV_{total} = -log\left(\frac{820}{902}(10^{-4.0} + 10^{-4.0})\right) = 3.74$$

5. Engineering Report

All public water systems proposing new sources or substantial modifications to a water system must prepare a comprehensive engineering report, as detailed in *Guidelines for Preparation of Engineering Report for New Surface Water or Groundwater Under the Direct Influence of Surface Water Sources*. This guidance document highlights specific items applicable to facilities using AFTs. The engineering report, once approved by DOH, serves as the basis for design of construction plans and specifications.

New systems proposing to use AFTs, including those treating surface water or GWUDI sources, must include additional AFT-specific information, including source water quality information, design criteria for the AFT, and information related to operations, monitoring, and controls.

a. Pretreatment Design Criteria (as applicable)

Provide description of water quality parameters pretreatment is addressing, including:

- Design criteria for pretreatment equipment:
  - Flow rates;
  - Loading rates;
  - Chemical doses;
  - Media specifications; and
  - Process equipment.
- Compare the treatment results for each parameter with the raw water quality results, the AFT manufacturers' requirements, and the computer model outputs to ensure the appropriate pretreatment is provided.

b. Cartridge or Bag Filter Design Criteria

Provide a description of the cartridge filter or bag filter configuration including:

- Average, max day, and peak hour flows;
- Filter manufacturer name(s) and model number(s) under consideration. For each proposed unit:
  - Filter material;
  - Filter element dimensions;
  - Number of elements per vessel;
  - Vessel configuration (horizontal or vertical);
  - Design filter rate (gpm/sf);
  - Maximum head loss at peak flow with new cartridges;
  - Maximum allowable differential pressure;
  - Oxidant tolerance;
  - pH tolerance; and
  - Any other limitations, caveats, chemical or operational no-nos that may affect both performance and/or warranty.
- Results of verification testing:
  - Removal efficiency established through challenge testing; and
  - Integrity test method and parameters, including resolution, sensitivity, test frequency, control limits, and associated baseline.

c. MF/UF Design Criteria

Provide a description of the membrane configuration including:

- Number of membrane units;
- Number of stages;
- Proposed membrane elements per unit;
- Range of system recovery;
- Average, max day, and peak hour flows for:
  - Feed;
  - Permeate; and
  - Backwash waste.

- Membrane manufacturer name(s) and model number(s) under consideration. For each proposed unit:
    - Membrane material;
    - Membrane element surface area;
    - Design flux (gpd/sf);
    - Maximum transmembrane pressure;
    - Oxidant resistance;
    - Feed water limitations (turbidity, metals, minerals, SDI);
    - Maximum temperature range (for operation and membrane cleaning);
    - Maximum pH range (for operation and membrane cleaning); and
    - Warranty.
- Results of verification testing:
    - Removal efficiency established through challenge testing; and
    - Direct integrity test method and parameters, including resolution, sensitivity, test frequency, control limits, and associated baseline.

d. <u>NF/RO Design Criteria</u>

Provide a description of the membrane configuration including:

- Number of membrane skids/racks;
- Number of stages;
- Membrane elements per vessel;
- Membrane vessels per skid/rack (including number per stage);
- Minimum and maximum system recovery;
- Average, max day, and peak hour flows for:
    - Feed;
    - Permeate;
    - Concentrate; and
    - Bypass (if any)
- List of any chemical constituents of concern expected in the proposed source not reflected in the model and the proposed treatment plan for the non-reflected constituents;
- Membrane manufacturer name(s) and model number(s) under consideration. For each proposed unit:
    - Membrane element surface area;
    - Design flux (gpd/sf);
    - Maximum lead element flux per stage;
    - Minimum tail element concentrate flow per stage;
    - Maximum feed pressure;
    - Feed water limitations (turbidity, metals, minerals, SDI);
    - Maximum temperature range (for operation and membrane cleaning);
    - Maximum pH range (for operation and membrane cleaning); and
    - Warranty

- Results of verification testing:
  - Removal efficiency established through challenge testing; and
  - Direct and indirect integrity test methods and parameters, including resolution, sensitivity, test frequency, control limits, and associated baseline.

Provide output of manufacturer computer modeling information, including:

- Description of manufacturer's computer model, the model version, and date run with assumptions;
- At least 4 modeling results for each membrane model proposed:
  - One for a new membrane under typical conditions;
  - One for a fouled membrane (5-year membrane age) under typical conditions;
  - One for maximum pressure conditions (max membrane age, coldest water, highest TDS); and
  - One for worst-case permeate water quality (max membrane age, warmest water, highest TDS)
- Based on the model results, include the following:
  - Confirm that maximum lead element flux rate and the minimum and maximum inlet and outlet element flow rates meet the membrane element's design guidelines;
  - Confirm that percent recovery meets manufacturer recommendations;
  - Confirm that the plant will meet the proposed system flow and water quantity goals;
  - Confirm that the pressures shown in the model do not exceed the recommended operating pressure or the maximum allowable net driving pressure;
  - Compare the results with the safety factor to the regulated limits. A minimum safety factor of 1.5 should be applied to the product water quality; and
  - Confirm that solubility warnings, if any, have been mitigated through pre-treatment or antiscalant use.

e. Post-treatment Design Criteria (as applicable)

Provide description of water quality parameters post-treatment is addressing, based on the permeate water quality shown in the computer model (RO and NF only).

- Detailed description and design criteria of post-treatment process and equipment:
  - Flow rates;
  - Loading rates;
  - Corrosivity or recommended water quality adjustments required to blend with existing distribution system water; and
  - Chemical dosages.
- If blending is proposed:
  - Where it will take place (storage tank, distribution system);
  - Percentage of water from each source;
  - Estimate post-blending quality;
  - Monitoring used to control blending; and
  - Any additional stabilization or disinfection that may be necessary.

f. Backwash System Design Criteria (as applicable)

- Backwash equipment specifications;
- Backwash flow rates;
- Backwash frequency;
- Backwash operating setpoints; and
- Backwash discharge method.

g. Chemical Cleaning System Design Criteria

- Description of types of fouling expected
  - Confirm that all foulants and scalants found in the source water are addressed.
- Description of cleaning process. For each distinct cleaning procedure:
  - Chemicals used;
  - Chemical solution concentrations;
  - Temperature; and
  - pH.
- Confirm that the temperature and pH do not exceed those allowed by the manufacturer; and
- Duration of cleaning and estimated interval between cleaning.
  - Criteria used to determine when chemical cleaning is needed.

h. Residuals Management Design Criteria

- Characteristics of the waste streams;
- Projected volume of the waste streams;
- Expected disposal methods; and
- Expected permits or authorizations needed.

i. Description of Operations, Monitoring and Control

Plant operations procedures, including:

- Startup;
- Integrity testing;
- Membrane repair procedures;
- Cleaning procedures;
- Shutdown and emergency procedures;
- Operator training plan;
  - Detail the amount and type of training the operators will receive for AFTs, pre-treatment equipment, and post-treatment equipment.

Process control monitoring and record keeping program

- Process control equipment descriptions:
  - Locations;
  - Calibration schedule; and
  - Periodic maintenance.
- Description of monitoring and recording by online SCADA, including:
  - Flow;
  - Differential and transmembrane pressure across each stage;
  - Feed pressure;
  - Temperature;
  - Membrane permeability or mass transfer coefficient (normalized flux divided by transmembrane or net driving pressure); and
  - Integrity test results.

6. Plans and Specifications

All public water systems proposing new or substantial modifications to a water system shall submit for review and approval by DOH, plans, specifications, supporting information and documents detailing the design and location of the proposed new facilities or modifications, in accordance with HAR 11-20, Section 30. Plans and specifications shall be signed and sealed by a professional engineer, licensed in the State of Hawaii.

7. Start-Up Testing

Start-Up Testing shall be conducted at the approved water treatment facility to confirm that plant operation complies with the proposed design and operating conditions and that product water quality complies with the treatment objectives. No water may be introduced into the distribution system from a new surface water treatment facility without DOH approval.

Start-up testing shall be done to confirm all equipment is functioning properly and product water quality is within acceptable levels for parameters measured with calibrated online instrumentation. Start-up and testing procedures shall follow the start-up testing plan included in the approved project plans and specifications. Prior to initial start-up, the following tests shall be completed and documented:

- Flushing, hydraulic testing, and disinfection of all piping and tanks;
- Functional testing of all process equipment, including all chemical systems;
- Loop checks of all relevant control systems and alarms;
- Equipment training;
- Calibration of all critical instruments; and
- Direct integrity testing.

A minimum of 8 hours of AFT equipment training shall be provided to the PWS, including but not limited to, the certified Water Treatment Plant Operator(s), who will be in direct-responsible charge of the plant.

After successful completion of equipment and system testing and operator training, initial plant start-up may be done using one AFT unit at a time or with multiple units simultaneously. Start-up testing shall include a minimum 8 hours of continuous operation for each new AFT unit, including regular backwash cycles, as applicable. Under no conditions may water from a new AFT be introduced into the distribution system without written approval from DOH.

8. Integrity Testing

All surface water and GWUDI sources utilizing AFTs shall perform periodic integrity tests on their systems. Integrity tests allow the PWS and DOH to determine if any of the membranes in a filtration system have been damaged and all system seals are intact. There are two types of integrity tests: direct and indirect. Surface water or GWUDI plants must perform both direct and indirect integrity tests and report results to DOH in their monthly operating reports.

a. Indirect Integrity Tests

Indirect integrity testing is the monitoring of a surrogate filtrate water quality parameter that can be generally correlated with the removal of the target pathogens. Turbidity is the most commonly used indirect integrity measurement, and has been used with various types of AFTs treating surface waters. As an alternative to turbidity, conductivity has also been employed in NF and RO facilities as an indirect integrity testing method.

DOH approved methods for indirect integrity testing are summarized in Table 4.

Table 4 - Requirements for Indirect Integrity Testing

Technology	Monitoring Parameter	Frequency	Filtrate Limit	Action if Fail
Cartridge / Bag Filters	Turbidity	At least once every 15 minutes	Less than 0.15 NTU 95% of the time, never to exceed 0.5 NTU	Isolate unit from the rest of the plant; address upstream turbidity or replace elements
MF/UF	Turbidity	At least once every 15 minutes	Less than 0.15 NTU 95% of the time, never to exceed 0.5 NTU	Perform direct integrity test if more than 2 consecutive 15-minute samples exceed 0.15 NTU
NF/RO	Turbidity	At least once every 15 minutes	Less than 0.15 NTU 95% of the time, never to exceed 0.5 NTU	Isolate unit from the rest of the plant; repair as necessary
	Conductivity	At least once every 15 minutes	Conductivity limit as determined by DOH, based on source water quality	Isolate unit from the rest of the plant; repair as necessary

A PWS may use an alternative indirect integrity testing method in combination with, or instead of turbidity, as approved by DOH on a case-by-case basis.

b. Direct Integrity Tests

Direct integrity testing is a physical test applied to an AFT unit to identify and isolate breaches. Direct integrity testing may include either a pressure/vacuum decay test or a marker-based direct integrity test.

Direct integrity tests shall be performed:

1. Daily;
2. As required by a failed indirect integrity test; and
3. On a higher frequency as required by DOH.

Direct integrity tests must be applied to each AFT unit in service. An AFT unit is defined here as a group of cartridge/bag filters or membrane modules that share common valving that allows the unit to be isolated from the rest of the system for the purposes of integrity testing. Control limits that ensure that an AFT unit is integral must be established by a PWS and approved by DOH, in accordance with the pathogen reduction credits requested for the AFT. Less stringent control limits may be applied when requested pathogen credits are less than the maximum allowable credit for the AFT (see Table 1).

If an AFT unit fails a direct integrity test, it must be isolated and repaired, as necessary, and must successfully pass a direct integrity test before it is placed back in service.

The requirements for integrity testing by technology are summarized in Table 5.

Table 5 - Requirements for Direct Integrity Testing

Technology	Type	Frequency
Cartridge/Bag	Differential pressure	Continuous
MF/UF	Pressure decay/ vacuum hold	Daily
NF/RO	Marker based, using TDS, TOC, silica, or other directly measured parameter	Daily or Continuous

Integrity of cartridge filters and bag filters shall be confirmed by continuous monitoring of differential pressure. Any pressure excursion above the maximum allowable differential pressure (based on challenge testing results or manufacturer recommendation, whichever is lower) or any rapid decrease in differential pressure shall be considered an integrity failure, necessitating immediate response (such as removing filter from service, halting production, or replacing bag/cartridges).

Direct integrity test markers for NF/RO shall be approved by DOH prior to plant operation. The selected marker must be smaller in size and no better removed than the targeted pathogen, whether viruses (~0.01 micron), bacteria (~0.1 micron), or *Cryptosporidium* (2 micron). Where an intrinsic marker is used, the marker must be directly measured using online equipment and must be present in the source water at sufficient concentrations to demonstrate the requested log reduction. Intrinsic markers may include constituents such as TDS, TOC, silica, sulfate, or calcium. In lieu of an intrinsic marker, an injected marker (such as rhodamine or other dye) can be utilized, provided the minimum once-per-day testing frequency is maintained. DOH may approve an LRV higher than 2.0-log for RO or NF where challenge testing and marker performance are shown to consistently demonstrate greater than 3.0-log reduction.

In the event that conductivity monitoring is used as an indirect measure of TDS reduction, a site-specific correlation between TDS and conductivity must be developed for both the feed and permeate using the approved membranes and proposed operating conditions. A minimum of 5 samples for each sample point are required in a Correlation Study, using all source waters proposed for the facility. Log reduction performance will be based on TDS reduction, using the demonstrated correlation factors rather than the log reduction of conductivity.

9. Reporting

The PWS shall submit operational reports to DOH at the following intervals:

- Start-Up Report;
- 90-Day Operations Report; and
- Monthly Operations Reports.

a. The Start-Up Report

The Start-Up Report may be submitted to DOH electronically or by hard copy, and shall be prepared, signed and sealed by a professional engineer registered in the State of Hawaii. The report shall include the following minimum information:

- Membrane integrity test log;
- Membrane repair log;
- Instrumentation calibration certificates and/or on-site calibration results;
- Minimum 8-hour trending data of flows, pressures, and indirect integrity testing output for each operating filter;
- Disinfectant CT calculations during initial operation, including pH, free chlorine residual and temperature; and
- Manual sampling result from the finished water clearwell for pH, chlorine residual, and temperature.

Water produced during start-up testing may be discharged into the distribution system if approved by DOH.

b. 90-Day Testing Report

After completion of the first 90 days of plant operation and prior to 120 days of operation, a 90-Day Testing Report shall be submitted to DOH to confirm plant operation meets the design operating conditions and that product water quality is in compliance with the treatment objectives. The 90-Day Testing Report shall include the following, at a minimum:

- Hourly flow and pressure trends during plant operation;
- Source water and finished water quality for all regulated parameters and other monitored parameters;
- Instrument calibration log;
- Alarm log;
- Chemical dosing log;
- Daily CT log;
- Integrity test log;
- Membrane cleaning log; and
- Trending data for feed pressure and membrane permeability for each filter unit.

Explanation for any exceedance of a regulatory or operational limit and description of measures taken to address the exceedance(s).

c. Monthly Operations Reports

In addition to reports required in the *Surface Water Treatment Rule Administrative Manual,* the PWS shall submit monthly operations reports to demonstrate compliance with Federal and State regulations for surface water and GWUDI treatment and plant- and equipment-specific approvals. In addition, these parameters allow DOH to better understand the source water and the performance of the plant.

Table 6 - Monthly Reporting Requirements

Item	Systems must submit the following information	Notes
Demonstration of performance	Monthly verification of operation within conditions of State approval for demonstration of performance credit	Within 10 days following the month in which monitoring was conducted
Bag filters and cartridge filters	Monthly verification that 100% of plant flow was filtered through the bag or cartridge filter	Within 10 days following the month in which monitoring was conducted
MF, UF, NF & RO	Monthly report summarizing the following: • All direct integrity tests above the control limit • If applicable, any turbidity or alternative state-approved indirect integrity monitoring results triggering direct integrity testing and the corrective action that was taken	Within 10 days following the month in which monitoring was conducted
Disinfection	Summary of CT values for each day	Within 10 days following the month in which monitoring was conducted