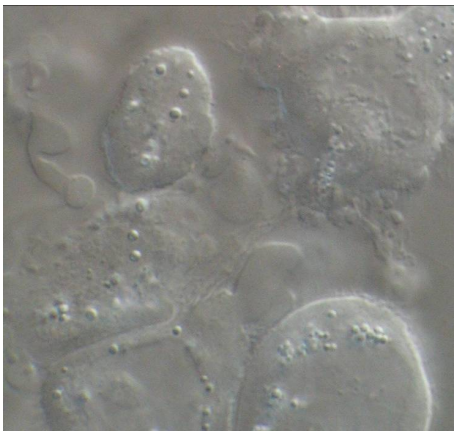
LT2ESWTR Compliance for Membrane Integrity Verification



Cryptosporidium Removed Using Purifics' Ceramic Membranes

Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR) identifies the log removal requirements for *Cryptosporidium* and the verification method to ensure the membrane integrity.

The EPA Membrane Guidance Manual identifies 5 types of tests and their method that must be conducted for LT2ESWTR compliance. The tests are:

1. Challenge Test (CT) – Performed once for the type of membrane
2. Non-Destructive Performance Test (NDPT) – Performed once at time of manufacturing
3. Initial DIT at Start Up (IDSU) – Performed once at start-up before water is sent to distribution
4. Continuous Indirect Integrity Monitoring (CIIM) – Performed on all surface water operations
5. Direct Integrity Test (DIT) – Performed when filtrate turbidity exceeds 0.1 NTU for greater than 15 minutes or weekly/daily as per applicable regulations

These are achieved in the ***Cuf***® process.

Challenge Testing (CT)

Challenge testing was conducted as per LT2ESWTR using a particulate marker method at a flux of 500 GFD and achieved greater than 5 log removal. The integrity of the membrane was performed using a **Conservative Marker** which is enumerated by a particle counter on both the inlet and outlet as specified in the EPA Guidance Manual for LT2ESWTR. The Conservative Marker, (2-3 micron TiO_2 nano-particulate), is added at the required loading in the feed stream to challenge the membrane at the rated flux. Particle counters are used to measure the log difference between the feed water and filtrate water to determine the Log Removal Value (LRV).

Non-Destructive Performance Test (NDPT) & Direct Integrity Test (DIT)

The Challenge Test utilized on the ***Cuf***® process is simple, automated, very low cost and only takes 15 minutes to perform. For all these reasons, ***Cuf***® systems utilize the exact same challenge test for both, non-destructive performance testing (NDPT) on all modules at the time of manufacture and direct integrity testing (DIT) during plant operations. The TiO_2 marker is NSF/ANSI 61 certified as part of the Purifics Drinking Water Systems UL System Certification.

Having one common integrity test is a key benefit of the ***Cuf***® process. Every membrane module is challenge tested. No surrogate integrity testing (such as bubble decay) is required. The DIT is conducted once per day or as regulations require. ***Cuf***® systems for LT2ESWTR compliance are equipped with the necessary instrumentation and automation consisting of particle counters, and flow control to conduct DIT at the installed location as identified in the figures 1 & 2. DIT testing is automated, logged and responds to test results as per the EPA Membrane Filtration Guidance Manual. The Manual states, "A marker based direct integrity test can be viewed as a "Mini Challenge Study"" Ref Sections 3.9.3 & 4.2.2

Initial DIT at Start-Up (IDSU)

As per Section 8.6 of the Guidance Manual, “Once the system is thoroughly flushed and disinfected, a direct integrity test should be conducted”. This is typically reviewed and approved by the regulator before water is sent to distribution.

Continuous Indirect Integrity Monitoring (CIIM)

Continuous Indirect Integrity Monitoring is performed using Turbidity monitoring of the feed and filtrate stream. This is performed using inline turbidity sensors and is monitored and logged by the ***Cuf***® systems PLC. The systems PLC will automatically take the required action if the turbidly limit is exceeded.

Capacity Derating for Cold Water Eliminated

The ***Cuf***® process operates at the required flux regardless of water temperature. When feed water temperatures drop and water viscosity increases, the ***Cuf***® automatically add more TMP to achieve the desired flux. ***Cuf***® is the only membrane system that has received a regulatory approval without this flux/capacity derating. This means ***Cuf***® installations do not require additional membrane modules to achieve the desired capacity rating.

Volumetric Concentration Factor (VCF) Eliminated

When a membrane system concentrates the suspended solids concentration that feeds the membrane surface, a **VCF is applied** to the sensitivity calculation of the indirect DIT pressure method such as Bubble Decay. However, VCF **is not applied** for Marker based DIT test because the actual concentration of the marker in the filtrate is measured. This is explained on pages 2-30 and 4-19 in the EPA Filtration Guidance Manual.

LT2ESWTR Instrumentation Set Up

The required Process Flow to conduct LT2ESWTR tests and the required instrumentation are shown below.

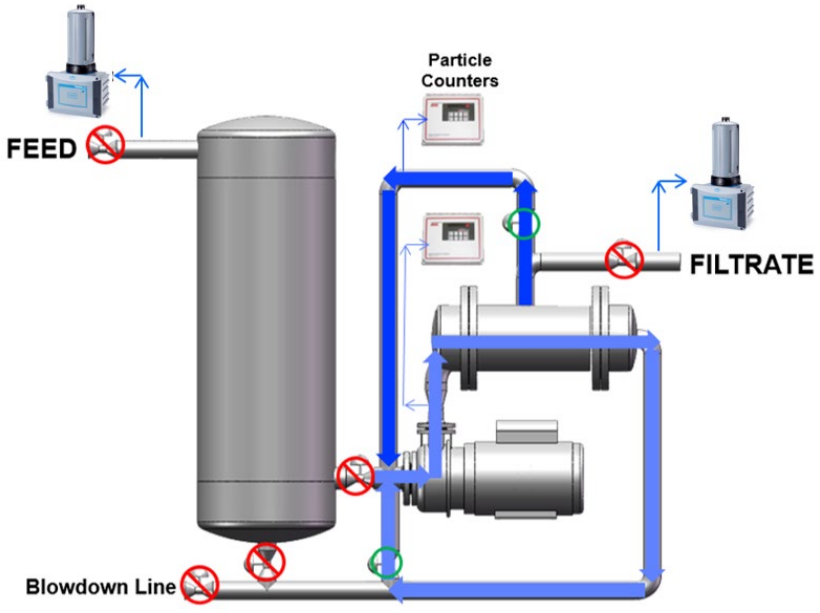


Figure 1: Process Flow

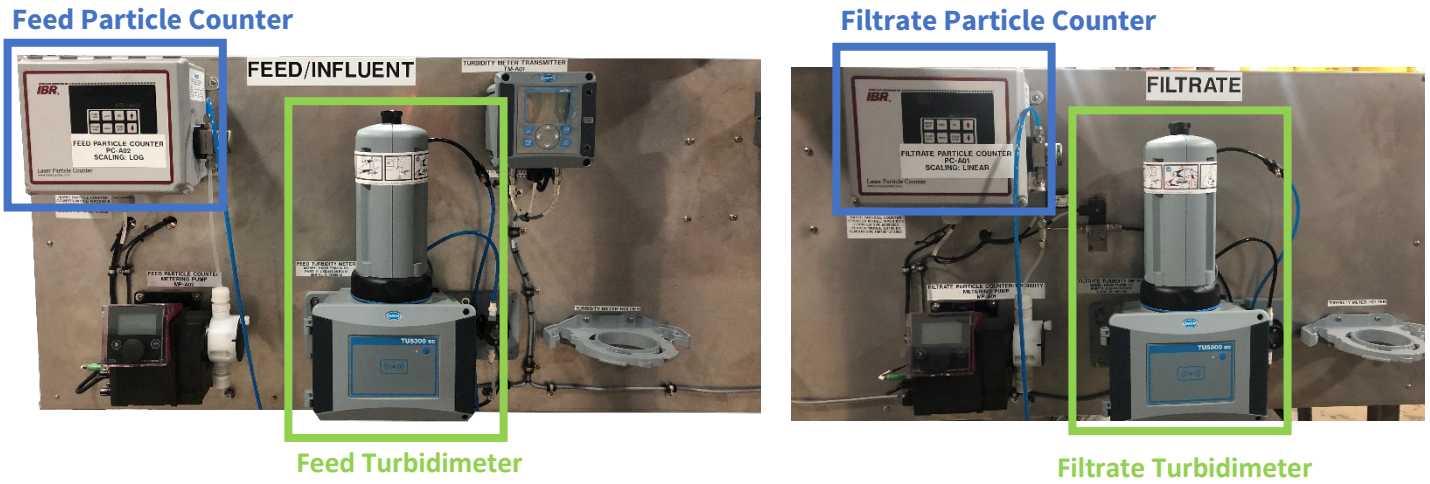


Figure 2: Typical Instrumentation

Reference Documents

- LT2ESWTR Challenge, NDPT, DIT & CIIM Method Documentation for ***Cuf***®
- USEPA Membrane Filtration Guidance Manual for LT2ESWTR (November 2005)