ONTARIO CLEAN WATER AGENCY
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Your Total Water Solutions Provider

The Cartridge Filter Challenge

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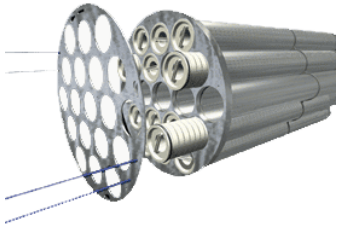
CARTRIDGE FILTER CHALLENGE

BACKGROUND

- Pressurized small (low flow applications) filtration to treat drinking water for compliance with the filtration requirements of the Surface Water Treatment Rule and the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR)
- Cartridge Filters have low loading capacity
- Can effectively remove particles from water in the size range *Cryptosporidium oocysts* (3-6 µm) and of *Giardia cysts* (8-12 µm).
- Currently, filtration evaluation is based on *Cryptosporidium oocyst* removal.
- This treatment offers no alteration of water chemistry
- Cartridge never cleaned (backwashed) - pathogens accumulate on filter surface until replaced



BACKGROUND

Operation and maintenance:

- Expended cartridge filter must be discarded
- Cost of cartridge replacement must be considered when designing a system
  - Can be expensive for small systems ($170-$300 per filter) and some housing units require 15 cartridge filters (changed 1 to 2 times a year)
- UV for pathogen removal also needs cartridge filters upstream for GUDI wells (not NSF 53 certified).

Legislation, Certification, and Product Guidelines

MECP requirements for GUDI system using cartridge filters is 2.0 log *Cryptosporidium* removal credit:

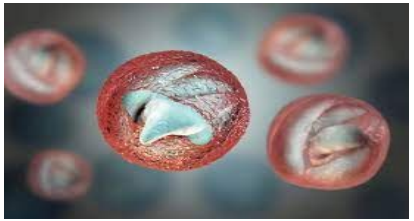
- Materials coming in contact with water conform to NSF/ANSI 61: Drinking Water System Components - Health Effects;
- Filtrate turbidity from each filter is monitored continuously;
- Alarming provided if differential pressures across the filter medium exceed the manufacturer rating;

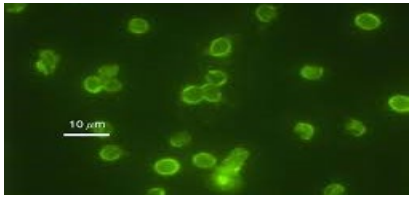
AND…

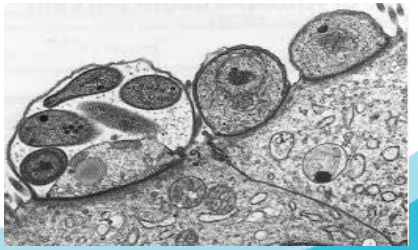
Legislation, Certification, and Product Guidelines`

Filter elements and housing should be certified for surrogate particle removal evaluation in accordance with testing procedures and manufacturing quality control specified in NSF/ANSI 53: Drinking Water Treatment Units - Health Effects or equivalent.

https://www.ontario.ca/page/procedure-disinfection-drinking-water-Ontario





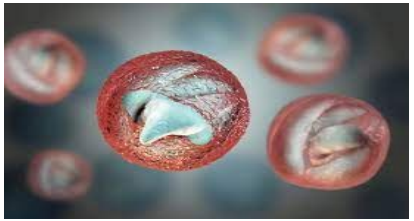


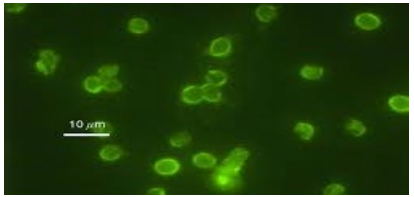
Legislation, Certification, and Product Guidelines

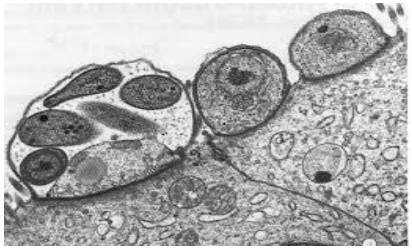
What is NSF/ANSI Standard 53?

Applies to systems designed to reduce specific health-related contaminants such as *Cryptosporidium*, *Giardia*, lead, volatile organic chemicals (VOCs), MTBE (methyl tertiary-butyl ether), that may be present in public or private drinking water.

NSF 61 is included in the NSF 53 standard







Who is OCWA?

Implications

OCWA operates some small GUDI treatment systems using cartridge filters (rely on NSF-53 certification for pathogen credits)

Legislation, Certification, and Product Guidelines

What Happened to NSF/ANSI 53 Certification?

Product	NSF/ANSI Status	Product	NSF/ANSI Status
PALL AbsoLife	No longer carried	**3M LifeAsure**	Expires 2024 – unsure if will continue to carry Was good for 30” and 10” filters. OCWA facilities had some 40” and 20” - not NSF 53 certified.
Graver	No longer carried (~2021)		
Harmsco	No longer carried (~2021)	**GE FloTrex**	No longer carried (~2021) – used at 3 OCWA Operated sites

NSF/ANSI 53 certification has been dropped for various sizes – What if it gets dropped completely?

Are GUDI facilities relying on pathogen removal credits from cartridge filters now out of compliance?

Legislation, Certification, and Product Guidelines

MECP Requirements for Pathogen Removal *without* NSF/ANSI 53

- On a case-by-case basis, MECP will temporarily accept non-NSF 53 certified cartridge filters based on good raw water quality (bacteria and turbidity) in the last five years. Filters must be NSF-61 certified.
- Currently, MECP does NOT grant pathogen removal credits for non-certified cartridge filters, and full credits achieved from two stage disinfection (chemical and UV), subject to Director Approval.
- Owners can reclassify well from GUDI to non-GUDI using new MECP ToR to eliminate the need for filter removal credits.

- Cartridge filters can be tested to NSF/ANSI 53 standard locally with specific housing and seals witnessed by 3rd party acceptable to MECP (i.e. University or Qualified Consultant). If the tests are acceptable, pathogen removal credits may be recognised by MECP.

DEVELOPMENT

Challenge Purpose

To generate the data that justified the claim for pathogen removal credits (at least 2.0-log removal of *Crypto* (3 to 6 µm) and 2.0-log removal *Giardia* (8 to 12 µm).

- University of Toronto DWRG developed protocol to:
  - Validate log-removal performance of site specific (filter and housing) cartridge filter systems.
  - According to standard procedures described in: U.S. EPA Membrane Filtration Guidance Manual, the U.S. EPA LT2ESWTR Toolbox Guidance Manual, and the NSF & U.S. EPA Generic Protocol for The Product Specific Challenge Testing of Bag & Cartridge Filter Systems.
  - Meet the requirements of the MECP to demonstrate pathogen removal credits for *Crypto* and *Giardia*, in the absence of NSF-53 certification.

METHODOLOGY

Challenge Test:

- Continuous injection of surrogates for *Crypto* and/or *Giardia* (microspheres) into filters with current housing apparatus at 4 sites. Measure effluent concentration to determine the removal capability of the filter.
- Detection limit of 1,000 spheres/L
- U.S. EPA Requirements for Challenge test:
  - Conduct full-scale cartridge filters with housing or pressure vessel that are identical in material and construction to the filters and housing the system will use for removal of *Crypto* and *Giardia*.
  - Cartridge filters configured same as system (individual or series) under representative hydraulic conditions (maximum design flow rate).
  - High quality water or “particle–free water” used for challenge solution
- U.S. EPA LT2ESWTR: individual cartridge filters are eligible for up to 2.0-log removal credit for *Crypto* if they demonstrate a minimum 3.0-log removal in challenge.

METHODOLOGY

Site W

- Yellowish-green microspheres are the tracer added to the water to test for removal through the cartridge filters
- Collected samples analyzed for microsphere concentration at U of T by epi-fluorescent microscopy.

METHODOLOGY

Site CS – Microsphere Injection

Log Removal Calculation

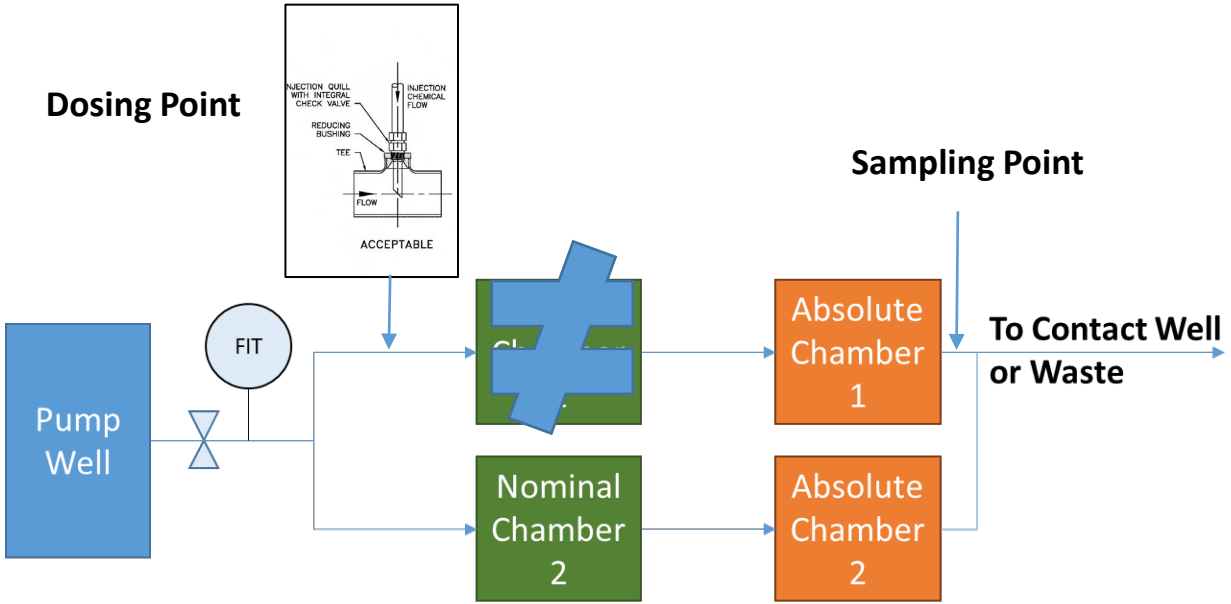
$$LRV = \log(C_f) - \log(C_p)$$

LRV = log removal value demonstrated during challenge testing

- C_f = feed concentration measured during challenge testing (number or mass / volume)
- C_p = filtrate concentration measured during challenge testing (number or mass / volume).

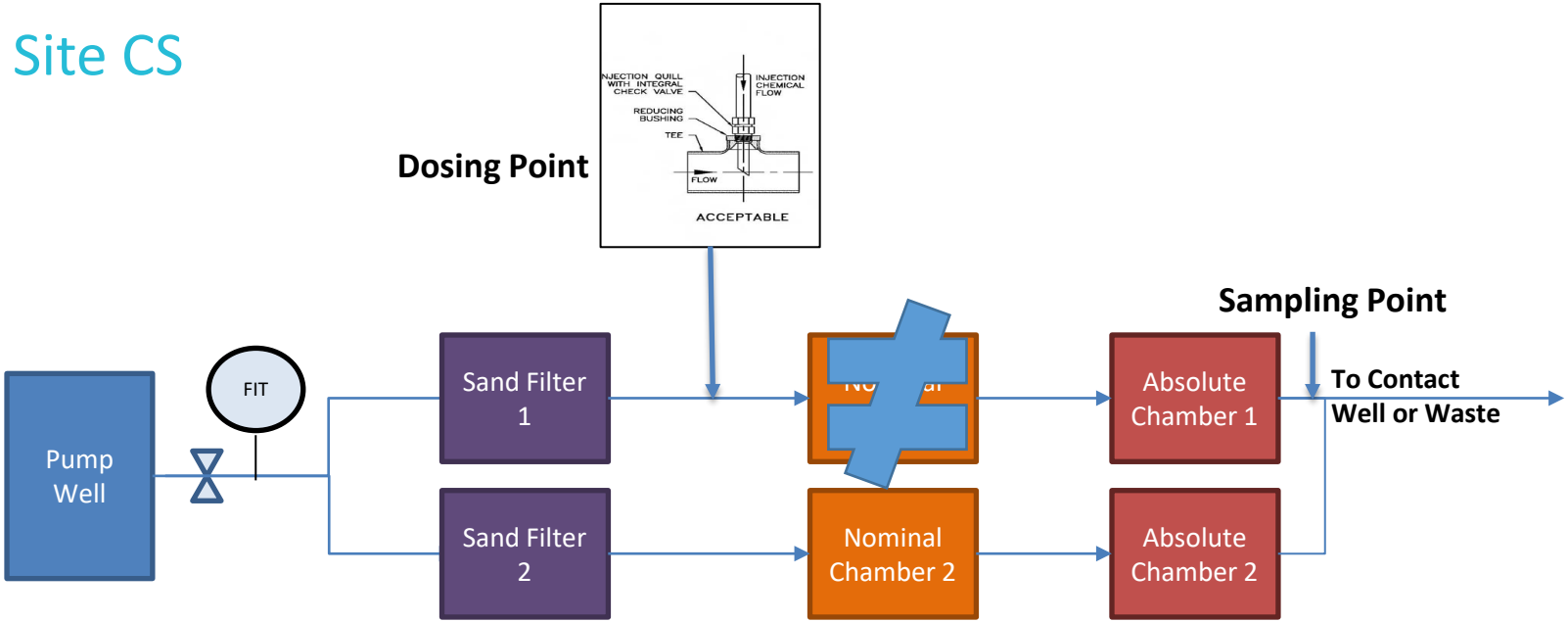
METHODOLOGY

Site W and Site WT



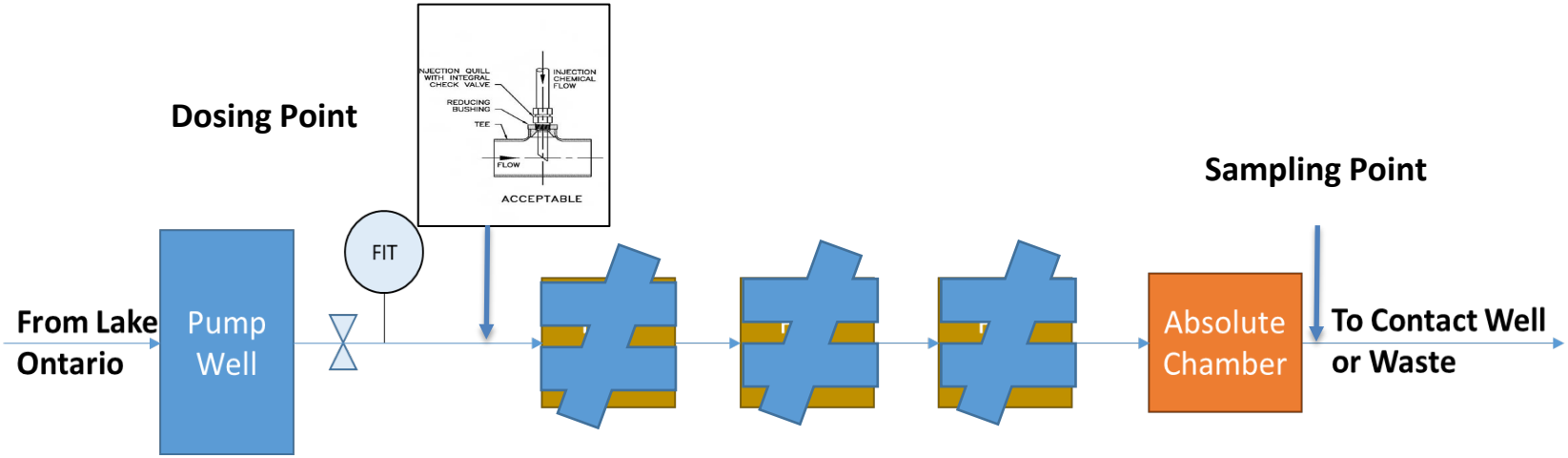
METHODOLOGY

Site CS



METHODOLOGY

Site B



METHODOLOGY

Sites Tested

Site W (services 719): Graver	1 µm
Site WT (services 294): Graver	1 µm
Site CS (services 300): Graver	1 µm and 0.8 µm
Site B: Graver	1 µm and 0.8 µm Global 1 µm

Preliminary Results

Site W: May 10, 2023 (Graver)

- 1 µm microspheres
- 6.8 L/s, two trains, 12 cartridges/train
- QCR 1 µm filters

Microsphere results		Log removal
Average influent	7.4-$\log_{10}$/L	-
Average Train 1 effluent	7.4-$\log_{10}$/L	0
Average Train 2 effluent	7.4-$\log_{10}$/L	0

Does not meet MECP 3.0-log removal requirement

Preliminary Results

Site W – Test 2: July 19, 2023 (Graver)

- 1 µm microspheres
- 6.8 L/s, two trains, 12 cartridges/train
- QCR 1 µm filters

Microsphere results		Log removal
Average influent	6.2-$\log_{10}$/L	-
Average Train 1 effluent	5.1-$\log_{10}$/L	1.1-$\log_{10}$
Average Train 2 effluent	5.2-$\log_{10}$/L	1.0-$\log_{10}$

Does not meet MECP 3.0-log removal requirement

Preliminary Results

Site W – Sept. 6, 2023 (Graver)

- 3 µm microspheres
- 3.4 L/s, two trains
- QCR 1 micron filters

Microsphere results		Log removal
Average influent	6.3-$\log_{10}$/L	-
Average Train 1 effluent	4.3-$\log_{10}$/L	2.0-$\log_{10}$
Average Train 2 effluent	4.2-$\log_{10}$/L	2.1-$\log_{10}$

Does not meet MECP 3.0-log removal requirement

Preliminary Results

Microscopy Images – Particle Size in Influent and Effluent

Influent	Effluent
Number of “dots” in influent vs. effluent counted for comparison.	Particle size same in influent and effluent. Some removal

Supplier Input

Product Specifications

Media: Polypropylene, Polyethersulfone (0.8)

Inner core, end caps, cage: Polypropylene

Gaskets/O-Rings: Buna-N, EPDM, Silicone, Teflon Encapsulated [illegible]

Micron rating: 0.8, 1.0

End styles: P2 (226/flat), P3 (222/flat), [illegible]

0.8 and 1.0 µm ratings

Graver Technologies

FILTRATION | SEPARATION | PURIFICATION

QCR™ Series Filter Cartridges

Helping to ensure the safety of the water supply

Product Specifications

Media: Polypropylene, Polyethersulfone (0.8)

Inner core, end caps, cage: Polypropylene

Gaskets/O-Rings: Buna-N, EPDM, Silicone, Teflon Encapsulated Viton, Viton

Micron rating: 0.8, 1.0

End styles: P2 (226/flat), P3 (222/flat), P7 (226/fin), P8 (222/fin)

Dimensions

Nominal lengths:

5"	9.75"	10"	20"	30"	40"
12.7	24.8	25.4	50.8	76.2	101.6 cm

Outside diameter: 2.7" (6.86 cm)

Inside diameter: 1.0" (2.54 cm)

Surface Area: 7.0 ft² (0.65 m²)

Operating Parameters

Maximum operating temperature: 176°F (80°C)

Maximum differential pressure:
75 psid @ 70°F (5.2 bar @ 21°C)
30 psid @ 176°F (2.0 bar @ 80°C)

Maximum reverse pressure: 40 psid @ 70°F (2.8 bar @ 21°C)

Recommended change-out pressure: 35 psid (2.4 bar)

HEALTH DANGERS OF CRYPTOSPORIDIUM

Water borne disease has been traced to Cryptosporidium and Giardia parasites that may be present in many surface water sources. Healthy individuals typically recover from the common gastrointestinal effects, however for individuals with weakened or undeveloped immune systems, it can be life threatening. These naturally occurring organisms are highly resistant to inactivation by conventional water treatment processes such as chlorination and thus require high performance mechanical removal technologies.

In order to ensure the safety of the water supply, standards have been established that define the minimum performance requirements for materials and components of water treatment systems. The QCR Cyst Reduction filter contains an absolute 1 micron filter media designed to provide a minimum log reduction credit of >3.0 for cysts based on the test requirements of the Long term 2 Enhanced Surface Water Treatment Rule (LT2).

FEATURES & BENEFITS

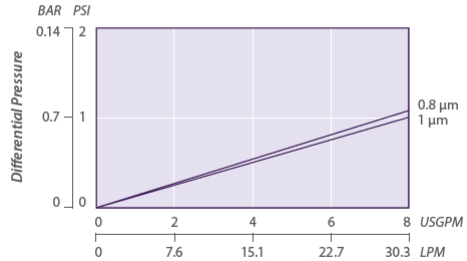
- Constructed of polypropylene or polypropylene and polyethersulfone — compatible with most fluids
- Double O-Ring style ends for the highest seal integrity
- 7.0 ft² (0.65 m²) of effective filter area
- Various O-Ring materials and configurations — easily retrofits most systems
- High surface area — high flow rates and long on-line service

CERTIFICATIONS

- USP Class VI: Meets USP Class VI Biological Test for Plastics
- FDA Listed Materials: All materials comply with FDA Title 21 of the Code of Federal Regulations Sections 174.5, and 177.1520, as applicable for food

QCR FLOW RATE

Typical Flow Rate Clean Water at Ambient Temperature (per 10" cartridge)



For liquids other than water, multiply pressure drop by the fluid viscosity in centipoise

Cartridge Filter Re-Test: 0.8 µm Filter

Site W – Sept. 6, 2023 (Graver)

- 3 µm microspheres
- 3.4 L/s, two trains, 7 cartridges/train
- QCR 0.8 µm filters
- QCR 1 µm filters (for comparison)

Microsphere results		Log removal
Average influent	6.5-$\log_{10}$/L	-
Average 0.8 micron filter	3.0-$\log_{10}$/L	3.5-$\log_{10}$
Average 1 micron filter	3.9-$\log_{10}$/L	2.6-$\log_{10}$

0.8 µm filter meets MECP 3.0-log removal requirement

Cartridge Filter Re-Test: 0.8 µm Filter

Site B – October 18, 2023 (Global)

- 3 micron microspheres
- 0.40 L/s, 1 filter per train
- QCR 0.8 micron filter
- QCR 1 micron filter
- Global 1 µm filter

Microsphere results		Log removal
Average influent	6.5-$\log_{10}$/L	-
Average 0.8 micron filter	3.0-$\log_{10}$/L	3.5-$\log_{10}$
Average 1 micron filter	3.9-$\log_{10}$/L	2.6-$\log_{10}$

0.8 µm filter meets MECP 3.0-log removal requirement

Supplier Input

01

QCR 1 Micron Filter demonstrated 1.7 / 2.0/ 2.6 – log removal of 1 Micron Microspheres. Is variability normal?

- QCR 1 testing indicates *no* retention of 1 µm microspheres. Previous independent testing using a 3 µm challenge indicates higher efficiency and acceptable by MECP.

02

Long-term fouling rate/pressure drop on 0. 0.8 µm vs. 1.0 µm filters.

- ~10% more fouling rate/pressure drop on 0.8 micron

03

QCR 0.8 vs. QCR 1 cost differential is ~10%

CONT'

CONT'

04 Are the 0.8 µm filters fundamentally different? How?

- QCR 1 media is polypropylene microfiber. QCR 0.8 is serial layered, PES membrane over polypropylene microfiber hence higher efficiency and built-in upstream pre-filter layer protecting the membrane.

05 Are 3 µm microspheres acceptable?

- QCR 0.8 testing indicates > 3 log removal of 3 µm microspheres which confirms the IBR independent lab results and is acceptable (*Cryptosporidium oocysts* are 3-6 µm).

NEXT STEPS

01 Establish if test is valid for same filter in different housing
Industry standard single open end 222 or 226 QCR 0.8 cartridges will perform as expected in any housing designed to accept those configurations.

02 DWRG to produce third party verification reports for the challenge testing.

03 Engage with MECP for pathogen removal credits for all 4 sites based on challenge testing.

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