PUBLIC HEALTH DIVISION
Drinking Water Services
Kate Brown, Governor

Oregon Health Authority

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October 6, 2021

Peter Blumanthal, PE
Westech Engineering, Inc.
3841 Fairview Industrial Drive, SE, Suite 100
Salem, OR 97302
pblumanthal@westech-eng.com

Re: City of Jefferson (PWS ID#00408)
Water Treatment Plant (PR#138-2019)
SRF Project # SD-16-155
Final Approval – PR# 126-2021

Dear Mr. Blumenthal:

Thank you for your submittal to the Oregon Health Authority's Drinking Water Services (DWS) of plan review information for the new membrane treatment plant for the City of Jefferson. Based on the submittal and the *Plant Commissioning Summary* letter received on October 1, 2021, **the conditions in the November 5, 2019 conditional approval letter have been met and the project is granted Final Approval and the facilities may now be placed into service. It is understood that the City will work with Chantal Wikstrom to complete a tracer study on the new baffled clearwell as soon as possible and complete two 6-month demonstration rounds of 40 lead and copper tap samples to be completed by June 30, 2022.**

This phase of the membrane treatment plant has a 2 MGD capacity and will utilize gas chlorine for disinfection. Future expansions of the membrane plant will increase the capacity to 4 MGD (then 6 MGD) and will utilize UV for disinfection. **The future membrane expansion will need to be submitted for plan review prior to installation.**

The membrane treatment plant is granted 4-log removal of *Giardia* and 4-log removal of *Cryptosporidium*. These log removals correspond with a 35-psi maximum transmembrane pressure (TMP), 120-gpd/ft^2 maximum flux rate, and by demonstrating through direct integrity testing an LRV $\geq$ 4.0-log and pressure decay rate $\leq$ 0.06 psi/min (0.3 psi over the 5-minute integrity test hold time). 4-log inactivation of viruses and 0.5-log inactivation of *Giardia* is to be achieved post-filtration with gas chlorine up to 2 MGD (1,389 gpm). The UV is credited w/3.5-log *Giardia/Cryptosporidium* inactivation @ 4,500 gpm (6.48 MGD) max flow through each reactor and is needed for *Giardia* inactivation for future plant flows over 2 MGD.

In summary, the project included the installation of a new:

1) raw water pump station,
2) membrane treatment plant (Pall UNA-620A, two 8-inch transverse racks (1 MGD ea.) with 62 ultrafiltration (0.1 µm nominal pore size) pressurized modules per rack);
3) below ground, concrete baffled clearwell (81,290 gallons w/ 35.1 minutes of contact time estimated using a 60% baffling factor and peak hour demand flow of 1,389 gpm);
4) chemical treatment including aluminum chlorohydrate (ACH) for pretreatment and soda ash for corrosion control;
5) gas chlorine and UV for disinfection (Two Trojan UVSwift™ 2L12 reactors); and
6) a new finished water pump station and associated piping and appurtenances.

Note that until a tracer study is complete, **the water system should use an estimated time (T) of 35.1 minutes for the clearwell when calculating daily CT values**. Note that the 2 MGD limit for disinfection applies to peak hour demand flow out of the clearwell and not plant production capacity, unless the flow going into the clearwell equals the flow going out of the clearwell (creating a constant level in the clearwell that doesn't drop with demand).

DWS understands that the City will utilize the Trojan UV units for additional disinfection until the tracer study is complete, but the City is not looking for inactivation credit at this time. The City will need to use the surface water treatment form for membrane treatment plants for monthly reporting, located at this link:

https://www.oregon.gov/oha/PH/HEALTHYENVIRONMENTS/DRINKINGWATER/MONITORING/Documents/turb-alt-unfiltered.pdf

The remainder of this letter includes:

1) Table 1 - Log removal credits (LRC) granted for the PALL UNA-620A membrane plant
2) Table 2 - Operating limits that help ensure that the log removal credits granted are met.
3) Appendix A - Explanation of operating limits and terms in Table 2.
4) Appendix B - Formulae and variables used in calculating the log removal value ($LRV_{ambient}$) of each membrane filter unit using current ambient operating conditions.
5) Appendix C – Product specifications for the UNA-620A membrane modules.

6) Appendix D – Specifications related to the Trojan UV-Swift™ 2L12 UV unit.
7) Appendix E – Contact time estimates for the baffled clearwell.

Thank you for your cooperation during this process and if you have any questions on the information above, or would like this information in an alternate format, please contact me at 971-201-9794 or via e-mail at carrie.l.gentry@dhsoha.state.or.us .

Sincerely,

Carrie Gentry, PE
Regional Engineer
Oregon Health Authority - Drinking Water Services

ec: Jeff Buskirk, City of Jefferson - jeffersonpwd@peak.org
Chantal Wikstrom, OHA/DWS - Chantal.T.Wikstrom@dhsoha.state.or.us
Michelle Bilberry, Business Oregon - michelle.bilberry@oregon.gov

Table 1 – Filter Log Removal Credit (LRC) – PALL (Asahi Kasei UNA-620A membrane modules

Pathogen	Removal Credit (log_{10})
Giardia lamblia	4.0
Cryptosporidium sp.	4.0
Viruses	0.0

The LRCs above are only valid provided operations are within the limits shown in Table 2. Ensure SCADA/PLC programming accounts for the operating limits in Table 2 (e.g., set system alarms to ensure operating limits are met).

Table 2 – Operating Limits

Operating Parameter	Limit
Direct integrity test (DIT) frequency	**Conduct at least 1 DIT each day of operation**
DIT duration/hold time	**5 min/300 sec**
DIT starting test pressure	**25 psi**
Minimum allowed DIT pressure	**17.47 psi** (It is understood that programming will trigger a failure if the DIT pressure drops below 25 psi)
Maximum allowable pressure decay rate (PDR) upper control limit (UCL)	**UCL = 0.14 psi/min** (It is understood that programming will use a UCL = 0.06 $^{psi}/_{min}$ = 0.3 psi / 5-minute test duration)
Minimum DIT pressure transducer accuracy for the established UCL[1]	**+/- 0.113 psi (+/- 0.075% of span (0-150 psi))**
Membrane Minimum Performance ($LRV_{ambient}$)[2]	**$LRV_{ambient}$ = 4.0-log (LRV must be ≥ 4.0-log LRC)**
DIT Sensitivity (LRV_{DIT})	**4.012-log @ 0.14 psi/min (4.38-log @ 0.06 psi/min)**
Maximum transmembrane pressure (TMP)	**35 psi at 20°C**
Maximum allowed filtrate flux [gfd]	**120 $^{gal/SqFt}/_{day}$ @ 20°C** (it is understood that programming will limit flux to 35.8 $^{gal/SqFt}/_{day}$
Individual filter effluent (IFE) turbidity	IFE ≤ 0.15 NTU for ≥ 15 consecutive minutes
Combined filter effluent (CFE) turbidity	CFE ≤ 1 NTU in 95% of readings and always less than 5 NTU
Automatic Shutdown Conditions (shut filter train down and conduct a DIT to demonstrate membrane integrity is intact)	○ PDR > UCL ○ $LRV_{ambient}$ < LRC ○ IFE > 0.15 NTU for > 15 min ○ CFE > 5.49 NTU (may prompt boil water notice)

[1] **Pressure transducer accuracy** is based on the manufacturer's stated accuracy (best fit straight line), expressed as % of span. The accuracy calculated in terms of [psi/min] must be less than or equal to the UCL in [psi/min]. Accuracy in terms of [psi/min] is calculated as follows:

Accuracy in psi/min = (% Accuracy x Max of span in psi) / DIT duration in minutes

[2] **$LRV_{ambient}$** is the best metric for demonstrating compliance with the log removal credit (LRC) granted.

- $LRV_{ambient}$ must be equal to or greater than the LRC for *Cryptosporidium* shown in Table 1.
- Ensure that any $LRV_{ambient}$ values displayed in SCADA are calculated using the formulae and variables shown in Appendix B.

Appendix A - Explanation of operating limits and terms in Table 2.

The operating limits summarized in Table 2 are further described as follows:

- Upper Control Limit (UCL) – 0.14 $^{psi}/_{min}$
  Every membrane system has an Upper Control Limit (UCL) measured in $^{psi}/_{min}$. The UCL is the highest **p**ressure **d**ecay **r**ate (PDR) allowed during a direct integrity test (DIT). Exceeding the UCL indicates DIT failure. The failing membrane unit shall not operate until it passes a DIT. Based on a review of Jefferson's specific system and information provided by the membrane manufacturer, the UCL is established to be 0.14 $^{psi}/_{min}$. Direct integrity tests that pass indicate that the membrane removes pathogens at the rate credited, e.g., 4.0 log (or 99.99%). Ensure that the SCADA/PLC system is programmed to account for this UCL. It is understood that the programming will use 0.06 psi/min as the UCL for Jefferson.

- Membrane Performance ($LRV_{ambient}$): The results of the direct integrity test can also be used to determine the log removal value of *Cryptosporidium* that is based on ambient or current operating conditions ($LRV_{ambient}$). The main difference between LRV_{DIT} and $LRV_{ambient}$ is the use of the current operating flow when calculating $LRV_{ambient}$. Lower flows could yield a lower (less conservative) LRV value. **Since your pathogen removal credit is in terms of 4.0-log, membrane performance must be determined to demonstrate compliance with the pathogen credit awarded using the same unit of measure [log]. Formulae and variables used to calculate $LRV_{ambient}$ are included in Appendix B of this letter.** In summary, **$LRV_{ambient}$** is the metric for demonstrating compliance. $LRV_{ambient}$ must be equal to or greater than the log removal credit for *Cryptosporidium* shown in Table 1.

- TMP: **The transmembrane pressure or "TMP" (pressure drop across the membranes) must not exceed 35 psi.**

- Flux: **The flux ($^{flow}/_{filter\ feed\ area}$) must not exceed 120 gallons per square feet per day [$^{gal/SqFt}/_{day}$]. It is understood that the programming will ensure that the flux will not exceed 35.8 $^{gal/SqFt}/_{day}$.**

- DIT Turbidity Trigger (IFE > 0.15 NTU for > 15 min): **A direct integrity test (DIT) must be performed on any filter unit in which the individual filter effluent (IFE) turbidity is greater than 0.15 NTU for more than 15 minutes. This must be programmed into the SCADA system.**

- DIT Daily Trigger: A DIT is also required each day of operation. If the pressure decay rate (PDR) drops below the upper control limit (UCL) of 0.14 $^{psi}/_{minute}$, then the DIT is considered to have failed and the unit must be automatically taken off-line, repaired, and retested to show that it passes a DIT before being placed back into service. In other words, should the PDR of the daily PDT (or "air hold test") exceed 0.14 $^{psi}/_{minute}$, this should indicate a "failed" DIT and the membrane must be taken out of service and may not be placed into service until it passes a DIT. **A new DIT may be immediately run after a DIT failure, or repairs may be needed first (e.g., fibers pinned, leaks at pipe fittings repaired, etc.) followed by passing a new DIT.** It is understood that programming will indicate a failed DIT if the PDR exceeds 0.06 psi/min (0.3 psi / 5-minute test duration).

- DIT test pressure: The minimum DIT pressure (i.e., the test pressure at the end of the DIT) must not drop below 17.47 psi. **Should the pressure during a DIT drop below 17.47 psi, the DIT is considered invalid or "failed" and must be repeated. PALL has established a DIT starting test pressure of 25 psi with programming to indicate a failed DIT if the test pressure drops below 25 psi.**

- Automatic Shutdown Conditions: **The filters must be taken off-line or otherwise shut down, repaired and/or re-tested if any of the following occurs:**

    1. PDR > UCL. The DIT PDR exceeds the 0.14 $^{psi}/_{min}$ UCL.
    2. $LRV_{ambient}$ < LRC. The $LRV_{ambient}$ is less than the 4.0 log removal credit (LRC)
    3. IFE > 0.15 NTU for > 15 min. The individual filter effluent (CFE) turbidity exceeds 0.15 NTU for more than 15 minutes.
    4. Combined Filter Effluent (CFE) turbidity exceeds 5.49 NTU (a boil water notice may be required)

- DIT Sensitivity (LRV_{DIT}): The results of the direct integrity test (pressure decay rate or "PDR") and the design flow can be used to determine the DIT sensitivity, expressed as a log removal value of *Cryptosporidium* (LRV_{DIT}). This LRV_{DIT} must be equal to or greater than the log removal credit (LRC) shown in Table 1 (i.e., LRC = 4.0-log). A PDR of 0.14 $^{psi}/_{min}$ equates to an LRV_{DIT} of 4.0-log. **Please ensure that any LRV_{DIT} values displayed in SCADA are calculated using the formulae and variables shown in Appendix B. LRV_{DIT} has been calculated to be 4.0-log as shown in Appendix B. PALL programming uses a PDR of 0.06 psi, which yields an LRV_{DIT} of 4.38-log.**

Appendix B - Formulae and variables used in calculating the log removal value ($LRV_{ambient}$) of each membrane filter train using current ambient operating conditions.

Formulae and variables used in calculating the log removal value ($LRV_{ambient}$) of each membrane filter train using current ambient operating conditions is shown in Table B.

Table B. Formulae and variables used in the $LRV_{ambient}$ programming

Specification	Value
$LRV_{ambient}$ equation	$LRV_{ambient} = \log_{10}\left(\frac{Q_P \bullet ALCR \bullet P_{atm}}{\Delta P_{test} \bullet V_{sys} \bullet VCF}\right)$
ALCR equation	$ALCR_{Turbulent} = 170 \bullet Y \bullet \sqrt{\frac{(P_{test} - BP) \bullet (P_{test} + P_{atm})}{(460 + T) \bullet TMP}}$
P_{Test} equation	$P_{test} = (0.193 \bullet \kappa \bullet \sigma \bullet \cos\theta) + BP_{max}$
Volume of pressurized air in module during direct integrity testing [gallons and liters]	Unknown $^{gallons}/_{module}$ (Unk $^{liters}/_{module}$)
V_{sys}, Total volume of pressurized air in the unit during direct integrity testing [gallons and liters]	192.31 gallons (727.97 liters)
VCF, Volumetric Concentration Factor [dimensionless]	1.08
VCF for backwash units in which filtrate goes to clearwell	N/A – no backwash recovery units
P_{atm}, Atmospheric pressure [psia]	14.58 psia
Y, Net Expansion Factor [dimensionless]	0.63 w/BP = 0 psi (0.588 is lowest from Crane[1] p. A-22)
d, Lumen diameter [mm]	0.64 mm (0.00064 m)
L, Potting depth or defect length [mm]	60 mm (0.06 m) – potting depth @ top
f, friction factor (dimensionless)	0.025
κ, Pore shape correction factor [dimensionless]	1.0
σ, surface tension at 5°C, [$^{dynes}/_{cm}$]	74.97 dynes/cm
ɵ, Liquid-membrane contact angle [degrees]	0 degrees
Q_p, Maximum design flow rate [gpm]	829 gpm (3,138.1 lpm, 1.194 MGD)
BP_{max}, Maximum backpressure during the DIT [psi]	3 psid (based on 2-meter module height)
P_{Test}, Applied direct integrity test pressure [psi] (*Should be ≥ minimum test pressure in Table 2*)	25 psi target starting DIT pressure 17.47 psi minimum ending DIT pressure
D_{base}, Baseline diffusive loss expected through fully intact membrane filter unit [psi/min]	0 psi

Crane Co. 1988. *Flow of fluids through valves, fittings, and pipe*. Technical Paper No. 410. Stamford, CT.

P_{test}, LRV_{DIT}, and UCL Calculations:

Minimum DIT pressure (P_{test}):

Pore shape correction factor (K)	1.0	dimensionless		
Surface tension (Φ)	74.970	dynes/cm		
Contact angle (θ)	0.0	degrees	0	radians
Maximum backpressure (BP_{max})	3.0	psi	83.12	in H2O
Constant (3 µm res. and unit conversions)	0.193	dimensionless		

Minimum (ending) DIT test pressure	17.47	psi
Anticipated starting DIT pressure	25.0	psi

$$P_{test} = (0.193 \bullet \kappa \bullet \sigma \bullet \cos\theta) + BP_{max} \qquad \text{Equation 4.1}$$

Where:

P_{test}	=	minimum test pressure (psi)
κ	=	pore shape correction factor (dimensionless)
σ	=	surface tension at the air-liquid interface (dynes/cm)
θ	=	liquid-membrane contact angle (degrees)
BP_{max}	=	maximum backpressure on the system during the test (psi)
0.193	=	constant that includes the defect diameter (i.e., 3 µm resolution requirement) and unit conversion factors

Calculation for Resolution and Sensitivity of the Membrane System

1. Determining Testing Pressure for Required Resolution (≤3 µm)

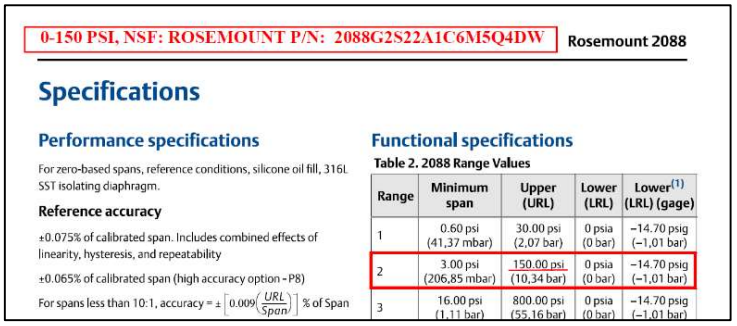
The testing pressure can be calculated per Equation (4.1)

$$P_{test} = (0.193 * \kappa * \sigma * \cos\theta) + BP_{max} \qquad \text{Equation (4.1)}$$

Table 1. Calculation Variables (P_{test})

Item	Description	Unit	Value
P_{test}	Test pressure for required resolution	psi	17.47
k	Shape correction factor	dimensionless	1
σ	Surface tension of water @ 5 °C	dynes/cm	74.97
θ	Water contact angle of membrane medium	degree	0.00
BP_{max}	Sum of backpressure and static head	psid	3.00

Since the testing pressure to be used is 25 psi or above and the pressure decay is anticipated lower than 1 psi during the duration of the test for Pall MF system, the resolution criterion is satisfied.



0-150 PSI, NSF: ROSEMOUNT P/N: 2088G2S22A1C6M5Q4DW Rosemount 2088

Specifications

Performance specifications

For zero-based spans, reference conditions, silicone oil fill, 316L SST isolating diaphragm.

Reference accuracy

±0.075% of calibrated span. Includes combined effects of linearity, hysteresis, and repeatability

±0.065% of calibrated span (high accuracy option - P8)

For spans less than 10:1, accuracy = $\pm\left[0.009\left(\frac{URL}{Span}\right)\right]$ % of Span

Functional specifications

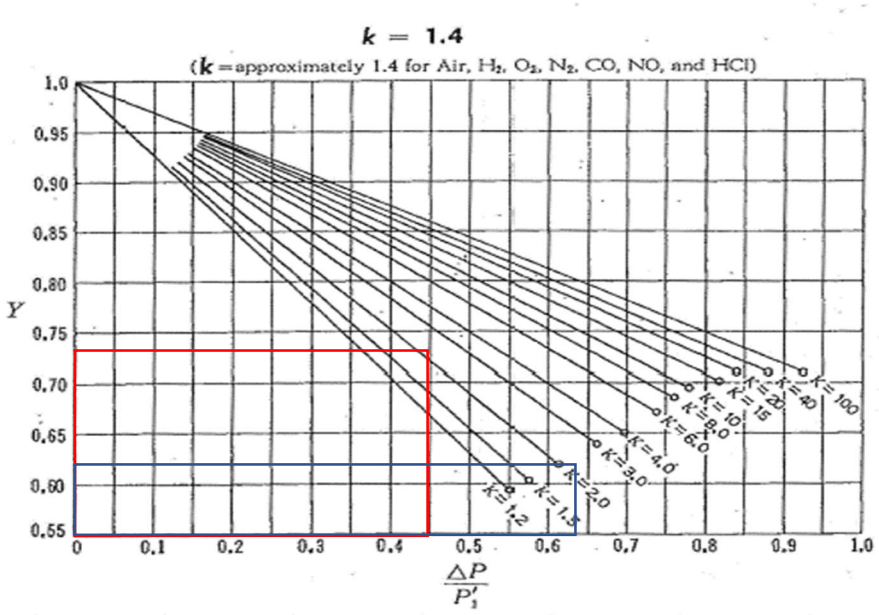
Table 2. 2088 Range Values

Range	Minimum span	Upper (URL)	Lower (LRL)	Lower[1] (LRL) (gage)
1	0.60 psi (41,37 mbar)	30.00 psi (2,07 bar)	0 psia (0 bar)	−14.70 psig (−1,01 bar)
2	3.00 psi (206,85 mbar)	150.00 psi (10,34 bar)	0 psia (0 bar)	−14.70 psig (−1,01 bar)
3	16.00 psi (1,11 bar)	800.00 psi (55,16 bar)	0 psia (0 bar)	−14.70 psig (−1,01 bar)

LRVDIT:	**OHA**	**PALL**	
Min PIT scale	**0.0**	**0.0**	psi
Max PIT scale	**150.0**	**100.0**	psi
Transmitter calibrated range	150.0	100.0	psi
Stated percent accuracy	**0.075**	**0.075**	percent
Transmitter accuracy	**0.113**	**0.075**	psi
Duration of DIT	**5.000**	**5.000**	minutes
Transmitter accuracy (+/-)	**0.023**	**0.015**	psi/min
UCL	**0.140**	**0.140**	psi/min
Transmitter accuracy as % of UCL	**16.07 %**	**10.71 %**	= Transmitter accuracy in psi/min divided by the UCL in psi/min expressed as a percent
Design capacity (Qpmax)	**829.0**	**829.0**	gpm
Min DIT test pressure (P_{test})	17.47	**25.00**	psi
Temperature	**70.0**	**70.0**	Deg F
TMP	**35.0**	**35.0**	psi
dPtestmin (transmitter accuracy)	0.023	**0.140**	psi/min
Atmospheric pressure (psia)	**14.58**	**14.58**	psi
Max Backpressure (BP_{max})	3.0	0.0	psi
System volume (V_{sys})	**192.31**	**192.31**	gal
Effective test pressure	24.6	46.4	psi
VCF	**1.08**	**1.08**	dimensionless
ALCR (Laminar, H-P method)	36.7	69.2	dimensionless
LRVDIT (Laminar ALCR)	**4.98**	**4.46**	log
Friction factor (f)	**0.0250**	**0.0250**	dimensionless
Length of breach flow path (L)	**60.00**	**60.00**	mm
Lumen diameter (D)	**0.64**	**0.64**	mm
Resistant coeff. (K)	**2.34**	**2.34**	dimensionless
$[(P_{test} - BP_{max})/(P_{test} + P_{atm})]$ =	**0.45**	**0.63**	Calculated
Net Expansion Factor (Y)	**0.74**	**0.63**	dimensionless
ALCR (Turbulent, Darcy method)	**19.89**	**24.74**	dimensionless
LRVDIT (Turbulent ALCR)	**4.711**	**4.012**	log

$$ALCR = 170 * Y * \sqrt{\frac{(P_{test} - BP)(P_{test} + P_{atm})}{(460 + T) * TMP}} \qquad \text{Equation (C.4)}$$

$$LRV_{DIT} = \log\left(\frac{Q_p * ALCR * P_{atm}}{\Delta P_{test} * V_{sys} * VCF}\right) \qquad \text{Equation (4.9)}$$



Limiting Factors For Sonic Velocity
$k = 1.4$

K	$\frac{\Delta P}{P'_1}$	Y
1.2	.552	.588
1.5	.576	.606
2.0	.612	.622
3	.662	.639
4	.697	.649
6	.737	.671
8	.762	.685
10	.784	.695
15	.818	.702
20	.839	.710
40	.883	.710
100	.926	.710

UCL:	OHA	PALL	
Design capacity	829.0	829.0	gpm
ALCR	19.89	24.74	dimensionless
Atmospheric pressure	14.6	14.6	psi
Log removal credit (LRC)	**4.0**	**4.0**	log
System volume	192.3	192.3	gal
VCF	1.1	1.1	dimensionless
Bpmax used in ALCR	3.0	0.0	psi
Y, Net Expansion Factor for ALCR	0.74	0.63	dimensionless
UCL =	**0.12**	**0.14**	psi/min

$$UCL = \frac{Q_p \bullet ALCR \bullet P_{atm}}{10^{LRC^*} \bullet V_{sys} \bullet VCF}$$ Equation (4.17)

Check LRV using PALL UCL of 0.14 psi/min:

Flow	**829**	gpm			
Temperature	**70.0**	degF			
TMP	**35.00**	psi			
Most recent test end pressure	**25.0**	psi			
Most recent test result	**0.14**	psi/min			
UCL	0.12	psi/min			
Min DIT PSI Allowed	17.47	psi	ALCR Inputs:		
Atmospheric pressure	14.58	psi	Temp =	70	deg F
Backpressure	3.0	psi	Y =	0.74	
			BP =	3	psi
ALCR	**27.26**	dimensionless	Patm =	14.58	psia
System volume	192.3	gal	TMP =	35.00	psi
VCF	1.1	dimensionless	Ptest =	25.00	psi
LRV	**4.05**	log			

$$ALCR = 170 * Y * \sqrt{\frac{(P_{test} - BP)(P_{test} + P_{atm})}{(460 + T) * TMP}}$$ Equation (C.4)

In addition to calculating the sensitivity, Equation 4.9 can also be used to determine the LRV verified by the most recent direct integrity test via applying values for the variables specific to this test event.

$$LRV = \log\left(\frac{Q_p \bullet ALCR \bullet P_{atm}}{\Delta P_{test} \bullet V_{sys} \bullet VCF}\right)$$ Equation 4.9

PALL Direct Integrity Testing Calculations dated 9/24/2021:

Applicable for:
Two 8" Transverse Racks with 62 Asahi Kasei UNA-620A modules each
Comment added by:
Evan Hofeld (OHA-DWS) 10/5/2021

Resolution and LRV Calculations for Direct Integrity Testing Using the MFGM Method for Water Treatment Plant at City of Jefferson OR - Water Treatment Plant - Rev. 1

Objectives

The objective is to determine (1) the testing pressure required to meet the resolution criterion of 3 µm or less as specified in the Long-Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR), (2) the pressure decay value (PDR) corresponding to required Log Reduction Value (LRV) for particles with the size of 3 µm at plant design conditions.

Calculation for Resolution and Sensitivity of the Membrane System

1. Determining Testing Pressure for Required Resolution (≤3 µm)

The testing pressure can be calculated per Equation (4.1)

$$P_{test} = (0.193 * \kappa * \sigma * \cos\theta) + BP_{max} \qquad \text{Equation (4.1)}$$

Table 1. Calculation Variables (P_{test})

Item	Description	Unit	Value
P_{test}	Test pressure for required resolution	psi	17.47
k	Shape correction factor	dimensionless	1
σ	Surface tension of water @ 5 °C	dynes/cm	74.97
θ	Water contact angle of membrane medium	degree	0.00
BP_{max}	Sum of backpressure and static head	psid	3.00

Since the testing pressure to be used is 25 psi or above and the pressure decay is anticipated lower than 1 psi during the duration of the test for Pall MF system, the resolution criterion is satisfied.

PALL Water

2. Calculating Sensitivity (LRV_{DIT})

The LRV calculation is performed by using Equation (4.9) in USEPA's Membrane Filtration Guidance Manual (USEPA, 2005):

$$LRV_{DIT} = \log\left(\frac{Q_p * ALCR * P_{atm}}{\Delta P_{test} * V_{sys} * VCF}\right) \qquad \text{Equation (4.9)}$$

The air-liquid conversion ration (ALCR) is calculated using Darcy Equation by assuming that the hollow fiber breaks completely at the interface of potting layer, which results in a shortest flow path for bypass flow. The calculation also uses the highest trans-membrane pressure (TMP) during a filtration cycle. This results in a conservative result that has a low LRV.

Air-to-liquid-conversion ratio (ALCR):

$$ALCR = 170 * Y * \sqrt{\frac{(P_{test} - BP)(P_{test} + P_{atm})}{(460 + T) * TMP}} \qquad \text{Equation (C.4)}$$

$$Y \propto \left[\frac{1}{\frac{(P_{test} - BP)}{(P_{test} + P_{atm})}}, K\right] \qquad \text{Equation (C.5)}$$

K: resistant coefficient

$$K = f * \frac{L}{d_{fiber}} \qquad \text{Equation (C.6)}$$

PALL Water

The parameters used in the LRV calculation are presented in Table 2.

Table 2. Parameters Used for LRV Calculation

Item	Description	Unit	Value
Q_p	design (instantaneous) flow per rack	gpm	829
VCF [a]	volumetric concentration factor	dimensionless	1.08
ΔP_{test}	The smallest pressure decay rate associated w/ a breach	psi/min.	0.06
V_{sys} [b]	system hold-up volume	gallons	192.31
P_{atm}	Atmospheric pressure	psi	14.58
BP [b,c]	back-pressure during pressure decay test	psi	0
T [b]	Temperature	°F	70
TMP [b]	terminal trans-membrane pressure during filtration	psi	35.00
f	friction factor	dimensionless	0.025
L [c]	the length of flow path for breach	M	0.06
D	diameter of hollow fiber lumen	M	0.00064
P_{test} [b]	testing pressure for pressure decay test	psi	25.0

Note: a *2004*
b *- Based on the design data*
c *- Assume worst-case fiber breakage (at the top potting layer)*

Find K:

$$K = f * \frac{L}{d_{f\ ibe}} \qquad \text{Equation (C.6)}$$

f: friction factor
L: the length of flow path of the breach (equal to the potting thickness)
d_{fiber} lumen diameter of the fiber.

$$K = 0.025 * \frac{0.06}{0.00064}$$

Find Y value using the chart on page A-22 from Crane:

$$Y \propto \left[\frac{1}{\frac{(P_{test} - BP)}{(P_{test} + P_{atm})}}, K \right]$$

Substitute Y into Equation (C.4):
Substitute ALCR into Equation (4.9):

Table 3. Additional Parameters Used for LRV Calculation

Item	Description	Unit	Value
K	Resistant coefficient	dimensionless	2.34
Y	Net expansion factor	dimensionless	0.63
$ALCR$	Air to liquid conversion ratio	dimensionless	24.58
LRV_{dir}	Sensitivity of direct integrity test	log	4.38

Therefore, the sensitivity of direct integrity testing is = LRV_{dir} in Table 3.

1. Calculate Upper Control Limit (UCL) and Alert Level (AL) for Direct Integrity Testing. The UCL for direct integrity testing, the pressure decay rate corresponding to the required LRV, is determined by rearranging Equation (4.9):

$$UCL = \frac{Q_p \bullet ALCR \bullet P_{atm}}{10^{LRC^*} \bullet V_{sys} \bullet VCF} \qquad \text{Equation (4.17)}$$

Where: UCL - upper control limit for pressure decay rate, psi/min.
LRC^* - required LRV for the membrane system

If the required LRV for the membrane system is 4-logs, substitute $LRC^* = 4$ and the same parameters in Table 2:

The plot of LRV as a function of pressure decay rate is presented in Figure 1 in which the UCL is marked with red dotted line.

Table 4. Results of UCL Calculation

Item	Description	Unit	Value
UCL	Upper control limit	psi/min	0.14

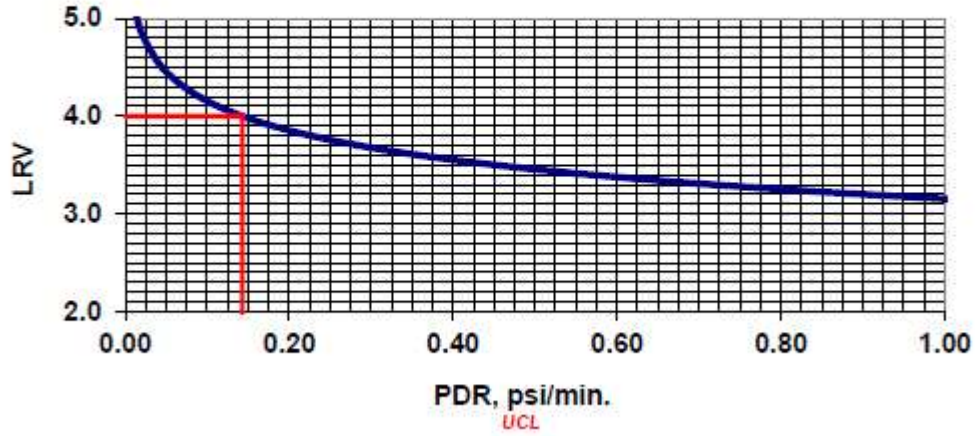


Figure 1: LRV as a function of pressure-decay rate (PDR)

UCL is indicated on the graph corresponding to LRV of 4-logs.

References

Sethi, S., G. Crozes, D. Hugaboom, B., Mi, J. M. Curl, and B. J. Mariñas (2004): *Assessment and Development of Low-Pressure Membrane Integrity Monitoring Tools* , AwwaRF Report No. 91032, Denvor, CO.

USEPA: *National Primary Drinking Water regulations: Long Term 2 Enhanced Surface Water Treatment Rule; Final Rule* , Federal Register, January 5, 2006

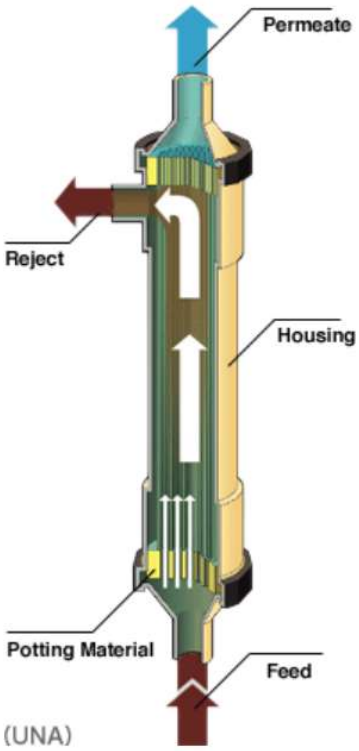
USEPA: *Membrane Filtration Guidance Manual* , EPA-815-R-06-009, November, 2005

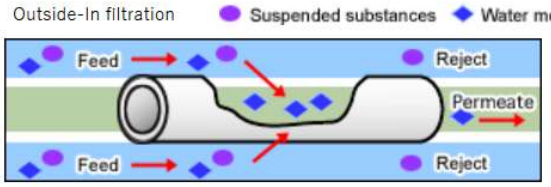
Appendix C – Product specifications for the PALL/Asahi Kasei UNA-620A

Characteristics regarding the membrane modules are provided in Table A.

Table A. Membrane Filter Module Specifications

Specification	Value
Membrane Manufacturer	Asahi Kasei
Membrane Model Number	UNA-620A
Challenge test standard (ANSI/NSF 419-YY, ETV, etc.)	NE-WTTAC – Univ. of New Hampshire
Challenge test report date	June 2004
$LRV_{C\text{-}Test}$	5.31-log
OHA-DWS Challenge Study Verification Information Assumes a 3-psi maximum backpressure (BP_{max}) =>	Date Verified = Feb 2010 LRC = 4.0-log (Giardia/Crypto) Max Flux = 120 GFD @ 20°C Max TMP = 35 psi Minimum DIT Pressure = 17.5 psi
ANSI/NSF Standard 61 certification (yes/no)	Yes
Membrane type (*e.g.*, hollow fiber, etc.)	Hollow fiber
Number of fibers per module	Unknown
Fiber inside (lumen) diameter	0.64 mm
Fiber wall thickness	Unknown
Active fiber length (length of fibers not in potting)	Unknown
Potting depth	60 mm (potting @ top of module)
Membrane classification (*e.g.,* ultra- or micro-filtration)	Ultrafiltration
Nominal membrane pore size (*e.g.*, 0.01 µm, etc.)	0.1 µm
Membrane material (*e.g.*, PVDF, polysulfone, etc.)	PVDF
Roughness coefficient	Unknown
Feed side membrane filtration area (ft^2)	538 ft^2 (50 m^2)
Filtration Flow Direction (*i.e.*, inside-out or outside-in)	Outside-in
Hydraulic configuration (*i.e.*, deposition or suspension)	Deposition
Submerged or Pressurized	Pressurized
Module Height (inches)	85-inches (2,160 mm)
Module Diameter (inches)	6.5-inches (165 mm)





Utilizing the lager area of the outer surface of the membrane fiber, the filtration load per unit area may be reduced. Additionally, a physical cleaning technique such as 'air-scrubbing' may be utilized. These features make this mode of operation well suited for high volume water clarification.

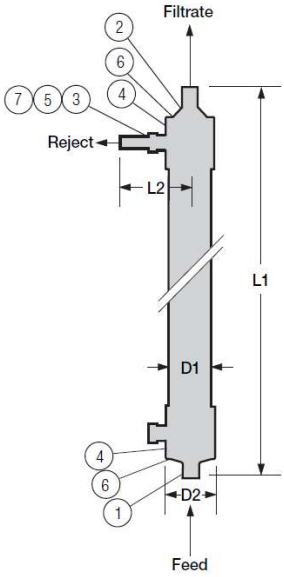
Microza modules for water clarification use hollow-fiber type membranes for outside-in filtration.

Operating Parameters

Performance[2]	• Process Capacity Typical Range: 2.2-6.8 m³/h / 10-30 gpm
Dimensions	• Membrane Area: 50 m² / 538 ft² • Module Length: 2160 mm / 85 in • Module Diameter: 165 mm / 6.5 in
Operating Conditions	• Maximum Operating Temperature: 40°C / 104°F • Maximum Transmembrane Pressure: 3 bar / 45 psi • Maximum Inlet Pressure: 3 bar / 45 psi • pH Range: 1-10
Materials	• Membrane: PVDF • Housing: ABS • Potting Material: Polyurethane • Gaskets: Silicone • Preservative: 40% calcium chloride

[2] Please contact Pall Corporation for operating manual and system sizing, as capacity per module is dependent on feed water quality, temperature and other factors.

Dimensions



Part Numbers / Ordering Information

Module

Module Part Number	Length (L_1) mm / in	Length (L_2) mm / in	Diameter (D_1) mm / in	Diameter (D_2) mm / in
UNA-620A	2364 / 93	272 / 10.7	165 / 6.5	221 / 8.7

Alternative Treatment Technology Units Meeting Challenge Study Criteria
Oregon Administrative Rule 333-061-0050(4)(c)(I)
Oregon Health Authority, Drinking Water Services (DWS)
» MEMBRANE FILTERS «

(Other models not on this list may meet the criteria.
Contact DWS for details on verifications for units not listed.)

Manufacturer	Model	Log$_{10}$ Removal Credit: Crypto.	Giardia	Virus[A]	Maximum Flux (gfd @ 20°C)	Maximum TMP (psi @ 20°C)	Maximum Flow/Module (gpm)	Minimum Static DIT[B] Pressure (psi)	Date Verified
Dow	XUSV-5203	3.5	3.5	0	60	30	23	30	2010 Feb
	SFD-2880XP	4.0	4.0	0	70	24	41	19	2010 Dec[C]
	SFD-2860XP	4.0	4.0	0	62	30	26	19	2010 Dec
	DW102-1100	4.0	4.0	0	70	30	50.2	30.25	2013 Jan[C]
GE Zenon	ZeeWeed 500C	4.0	4.0	0	60	12	10.4	10.29	2013 Oct
	ZeeWeed 500D	4.0	4.0	0	60	12	18.3	10.29	2013 Oct
	ZeeWeed 1000 V3	4.0	4.0	0	30	13	17	10	2009 July
	ZeeWeed 1000 V4	4.0	4.0	0	60	13	17.4	10	2013 Oct
DuPont inge (formerly BASF)	dizzer XL 0.9 MB 60 W	4.0	4.0	0	105	22	47	17.5	2015 Sept[C]
	dizzer XL 0.9 MB 70 WT	4.0	4.0	0	105	22	55	17.8	2015 Sept[C]
	dizzer XL 0.9 MB 80 WT	4.0	4.0	0	105	22	55	17.8	70 WT equiv.
Pall	UNA-620A	4.0	4.0	0	120	35	44	17.5	2010 Feb
	USV-6203	4.0	4.0	0	120	35	44	17.5	2010 Feb
	XUSV-5203	4.0	4.0	0	120	35	33	17.5	2010 Feb
Scinor	SMT 600-P50	4.0	4.0	0	120	43.5	46	21	2015 June[C]
	SMT 600-P80	4.0	4.0	0	120	43.5	72	21	P50 equivalent
	SMT 600-S26	4.0	4.0	0	106	11	23.5	15.9	2016 June[C]

[A] Virus removal credits are not available in Oregon due to lack of a direct integrity test for virus-sized particles. All approvals and removal credits are subject to change should information indicate the model is not capable of meeting regulatory requirements.
[B] DIT = Direct Integrity Test. Acceptable pressure decay rates during a DIT are, in part, a function of system volume and must be confirmed with DWS during plan review for each installation. Additionally, minimum static pressure may be higher than listed here if backpressure is above minimums.
[C] Verification via NSF 'Public Drinking Water Equipment Performance'

For more information, please call the OHA Drinking Water Services at ph. 971-673-0405 (8am-5pm PT, Mon-Fri)

Updated: 16 October 2020

Appendix D – Product specifications for the Trojan UVSwift™ 2L12 UV Reactor from the UV Validation Report Reviewed by OHA-DWS

Table 1 – Disinfection Inactivation Credit	
Target Organism	**Inactivation Credit (log_{10})**
Giardia lamblia	3.5 (variable)
Cryptosporidium sp.	3.5 (variable)
Viruses	0.0 (up to 2.0 log, but not reviewed)**

Alternative Treatment Technology Units
Meeting Validation Test Criteria
Oregon Administrative Rule 333-061-0050(5)(k)(I)
Oregon Health Authority, Drinking Water Services (DWS)

ULTRAVIOLET REACTORS

(Other reactors not on this list may meet the criteria. Contact DWS for details on verfications for reactors not listed.)

Manufacturer	Model	Log10 Inactivation Credit **			Max. Flow (gpm)
		Crypto.	*Giardia*	Virus	
Neotech	D438	3.5	3.5	0	435
Trojan	UVSwiftSC™ B03	3.5	3.5	0	132
	UVSwift™ 2L12	3.5 *	3.5 *	0	4,500
	UVSwift™ 4L12	3.5 *	3.5 *	0	4,500
Viqua	Pro50/SV50/Sterilight50	3.5	3.5	0	70
	Pro50/SV50/Sterilight50	3.0	3.0	0	80
	Pro24-186	5.5+	5.5+	4.0	24
Calgon	Sentinel 24" 9-lamp	4.0	4.0	0	19,600
atg	UV SP-25-6	3.0	3.0	0	495
Wedeco	BX100	3.0	3.0	0	387
	B400XL	3.0	3.0	0	1,760
	LBX1000	4.0	4.0	0	4,650

* If more log inactivation credit is requested after 2015 action spectra correction factors can be re-calculated to improve accuracy.
** 1 log is 90% inactivation of pathogens (e.g., *Crypto.*), 2 log is 99%, 3.5 log is 99.97%, 5.5 log is 99.9997% inactivation

Table 2 – System Operating Parameters	
Parameter	**Value**
Flow Range	0.2 – 6.5 mgd
UV Transmittance Range	70% - 98%
Action Spectra Correction Factor, CF_{AS} (* interim – readjust in 2013)	For MS2: 1.35 For T1: 1.35
Fouling/Aging, S/S_0	Use lowest sensor reading; Monitor relative lamp output regularly

Table 3 – Trojan 2L12 Characteristics	
Polychromatic Bias, B_{poly}	1
Uncertainty of Validation, U_{Val}	$U_{Val} = U_{In} = {}^{t \times SD}/_{RED}$ x 100%, where MS2: t = 1.987; SD = 3.495 T1: t =1.989; SD = 0.6972
RED, B_{RED} *(See App. G. Variable, one example given.)*	T1 = 1.03, MS2 = 1.82; for 90% UVT, 2.0 log *Crypto*. inactivation
Dose Ranges	For MS2: 7.1 – 111 mJ/cm^2 For T1: 2.8 – 26 mJ/cm^2
Lamps	4; Diameter = 0.866"; Arc Length = 11.575"
Lamp model	Phillips Lighting. Trojan part # 820810
Mercury type & content	*Unknown* – WS configuration critical to public health protection. Create spill plan.
Lamp and sensor sleeve	GE Quartz (Type 021 AL material, 4 mm thick, air-quartz interfaces) (Type 021 is a synthetic fused silica sleeve) Trojan part # 820821-558
Lamp and Sensor Sleeve UVT% at 240 nm	88%
Sensors: Reference Duty	 One; Trojan part # 015362-R1-798S One; Trojan part # 015362-S1-798S