PROTOCOL FOR PERFORMANCE TESTING OF DRINKING WATER TREATMENT TECHNOLOGIES

Prepared by:
Environment Canada in collaboration with Bureau de normalisation du Québec

For:
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1. INTRODUCTION

In Canada and other jurisdictions, different regulatory agencies and authorities having jurisdiction may have different requirements and performance criteria for approval and acceptance of domestic drinking treatment technologies. To support their decisions, these agencies and authorities can benefit from scientifically defensible, verifiable performance data applicable to a range of possible end use requirements and operating conditions.

The intent of this *Protocol for Performance Testing of Drinking Water Treatment Technologies* is to provide a common protocol for testing and verifying the actual performance of treatment devices under controlled conditions, in an independent, transparent manner. It is anticipated that independent verification of the performance data will assist regulatory agencies, authorities having jurisdiction and other affected stakeholders in evaluating treatment technology options.

This protocol was prepared following an agreement between Globe Performance Solutions, representing the Canadian ETV Program, and the Bureau de normalisation du Québec (BNQ), representing the Québec Government, to harmonise the verification protocols for domestic drinking water treatment technologies used by the two entities. The BNQ is a Standard Development Organization accredited by the Standards Council of Canada.

The protocol presented in this document is based on the existing *Performance validation procedure for drinking water treatment technologies*[1] in Quebec.

This performance testing protocol is an effective approach for conducting testing in order to produce verifiable performance data on specific technologies under defined operating conditions. Environment Canada's *Canadian ETV Program* supports the use of this protocol to reduce uncertainty and to improve acceptance of independently generated performance data, thereby contributing to informed technology decisions.

It is understood that the ultimate decision to approve, select and implement a particular technology rests with the technology buyer, guided by the requirements of the respective authorities having jurisdiction within the affected jurisdiction(s).

2. PURPOSE AND FIELD OF APPLICATION

This protocol applies to any drinking water treatment technology, or its application. The technology should meet the following requirements:

- the Guidelines for Canadian Drinking Water Quality;

[1] http://www.mddelcc.gouv.qc.ca/eau/potable/guide/procedure.htm

- the material in contact with the water used by the technology should be NSF[2]/ANSI[3] 61 certified or equivalent;
- the chemicals used in the technologies should be NSF/ANSI 60 certified[4].

3. REFERENCES

In this document, a dated prescriptive reference means that the given edition of the reference applies, whereas a non-dated prescriptive reference means that the latest edition of the reference applies.

For the purposes of this document, the following references (including any amendment, erratum, corrigendum, etc.) contain requirements that should be taken into account and are quoted in the appropriate locations in the text:

Canadian ETV Program - General Verification Protocol [www.etvcanada.ca]
The General Verification Protocol is used by Verification Entities in the verification process and offers a comprehensive and rigorous procedure so that all verifications are done in a consistent manner.

ISO (International Organization for Standardization) [www.iso.org]

ISO/CEI 17025	*General requirements for the competence of testing and calibration laboratories*

NSF (NSF International) [www.nsf.org]

NSF/ANSI 60	*Drinking Water Treatment Chemicals — Health Effects*
NSF/ANSI 61	*Drinking Water System Components — Health Effects*

Health Canada [www.hc-sc.gc.ca]

Canadian Recommendations	*Guidelines for Canadian Drinking Water Quality —Technical Documents*

[2] NSF = NSF International (formerly National Sanitation Foundation)
[3] ANSI = American National Standards Institute
[4] Based on stakeholder consultation conducted by Quebec. This requirement was introduced in Quebec's regulation in 2012 and comes into effect on March 8, 2017.

4. DEFINITIONS

For the purposes of this document, the following terms apply:

Applicant: Natural person or legal entity that makes a request for verification.

Technology: A system consisting of one or more pieces of equipment used to process water for human consumption.

For other definitions, refer to the Canadian ETV Program General Verification Protocol (2012).

5. TEST PROTOCOL

5.1 TEST OBJECTIVE

The objective of the testing is to assess the technology from a performance and operational reliability perspective. Testing is supervised by an independent third party who must check the precision of the tests conducted and objectively report the results obtained.

5.2 TEST PLAN

The testing varies based on the technology and the water supply source (surface or groundwater). Sampling must be done when the technology is in a normal state of operation.

A **test plan** must be provided by the applicant, taking into account the guidelines of this chapter as well as the guidelines of Appendix 4, if applicable, which describe the **complementary testing** proposed for different situations. The test plan will be adapted based on the technology and its application.

For an ultraviolet irradiation disinfection reactor, section 5.5 entitled *Parameters and analyses* is not mandatory. Instead, the complementary testing required in this case is described in Appendix 4, under CASE 1–OPERATIONAL TESTING OF UV REACTORS.

5.3 DURATION OF TESTING

The applicant must demonstrate that the proposed technology has reached a sufficient level of mechanical and operational reliability. The demonstration must be based on the results of testing conducted during a **period of a minimum of 12 consecutive months**[5].

[5] The applicant is free to choose a test location, as long as the operation is done by an independent operator and not the applicant.

In the event that the technology is used to treat surface water, the equipment must function at its maximum production capacity (design criteria) for a minimum of five consecutive days at four specific moments during the 12-month monitoring: in winter, in the spring (targeting the worst raw water conditions), in the summer and in the fall (targeting the worst raw water conditions).

The sampling set forth in Table 5.8.1 will be distributed as follows:

- during periods where maximum criteria will be reached, there will be one sampling per day (i.e. four five-day periods, for a total of 20 samplings) and these samplings will count towards the month;
- during the other months, there will be one sampling per month (i.e. eight in total).

5.4 THIRD PARTY TESTING

The testing must be conducted under the supervision of a relevant third party.

Implementation or execution of performance testing by an independents third party must include supervision of sample taking, logging of sampling activities, monitoring of all operation parameters and the surveying of the prevailing conditions in the installation when the samples were taken for laboratory analysis. The third party must write a test report as described in Section 5.8.

5.5 PARAMETERS AND ANALYSES

5.5.1 OPERATING PARAMETERS

During testing, the testing organization must ensure that the measurement of the operating parameters correspond to the operating conditions of the technology being tested. It must ensure that these measurements have been documented when the samples are taken for analysis.

5.5.2 SAMPLING PROGRAM AND ANALYSES

Tables 5.8.1 and 5.8.2 specify basic parameters for any site monitoring. Table 5.8.1 must be used for surface water and Table 5.8.2 for groundwater. Additional analyses of particular parameters could also be relevant according to local characteristics (for example, analysis of aluminium if alum is used).

The sampling must be done uniformly during the entire testing period, particularly during the first and last week of testing.

Special case: testing of technology parameters that are part of a complete treatment chain

If the technology targeted by the test plan is incorporated into a complete treatment chain, the testing must also pertain to the operating parameters of the different equipment involved as well as the intermediate samplings, whose number and frequency must be specified in the test plan.

Integrity measurement for membrane filtration processes

In the case of membrane filtration technology with log removal credits, an integrity measurement of the membrane systems must be conducted according to a recognized and approved method.

Presentation of data on raw water parameters

It is not necessary to present all raw water parameters that were measured in the test report.

In order to report raw water conditions in the test report that are representative of the conditions met during the 12 month test period, it may be useful to retain a number of more significant parameters.

With respect to the treatment processes used in surface water (clarification, granular filtration, membranes, etc.), the values to present for the raw water parameters are the following[6]:

i) Critical raw water parameters

Turbidity:	-	value based on the 95th percentile of values observed
	-	maximum value of values observed
TOC[7]:	-	value based on the 90th percentile of values observed
	-	maximum value of values observed
Other:	-	value based on the 90th percentile of values observed and the maximum value for any other parameter deemed essential to ensure the desired performance of the technology

ii) Other raw water parameters measured

The following list is not exhaustive and can be adjusted according to the procedures assessed.

True colour:	-	value based on the 90th percentile of values observed
Temperature:	-	range of values observed
pH:	-	range of values observed

[6] Based on the standard set by the Quebec Drinking Water Treatment Technologies Committee in 2000.
[7] Total organic carbon

Total alkalinity: - range of values observed

Iron: - range of values observed

Manganese: - range of values observed

UV absorbance: - range of values observed

SUVA[8]: - range of values observed

With respect to the treatment processes used for groundwater, the values to present for raw water parameters will depend on the targeted performance. As such, the raw water data will be required for each parameter for which a treatment performance claim is made. Information on log removal credits is presented in Appendix C.

i) Critical raw water parameters

Parameter: - value based on the 90th percentile of values observed and the maximum value for any other parameter deemed essential to ensure the desired performance of the technology

ii) Other raw water parameters measured

Parameter: - value based on the 90th percentile of values observed and the maximum value for any other parameter deemed relevant

The same applies to technologies for which log removal credits are requested, regardless of whether these technologies are used for surface water or for groundwater.

Presentation of data on treated water parameters

The applicant should demonstrate, in a distinct manner for the following parameter groups and by limiting the targeted parameters that will be processed by the technology, that the results obtained meet the performance claim(s) for the following parameter(s):

i) Microbiological parameters

The results presented should allow for the elimination rate achieved to be noted for each of the targeted microorganisms. In order to know which parameter to present and the achievable elimination rates, the applicant should refer to Appendix C (Methods for Establishing Microorganism Log Removal Credits) of this protocol.

The results presented should demonstrate that the local regulations, Guidelines for Canadian Drinking Water Quality, World Health Organizations standards, or other generally accepted thresholds, will be met at all times.

ii) Inorganic substances parameters

[8] Specific UV Absorbance

The results presented should demonstrate that the local regulations, Guidelines for Canadian Drinking Water Quality, World Health Organizations standards, or other generally accepted thresholds, will be met at all times.

iii) Organic substances parameters

The results presented should demonstrate that the local regulations, Guidelines for Canadian Drinking Water Quality, World Health Organizations standards, or other generally accepted thresholds, will be met at all times.

In the case of chlorination by-products

For trihalomethanes (THM) and haloacetic acids (HAA), it is recommended to calculate the average of the maximum values obtained for four consecutive quarters. As such, the results presented for the chlorination by-products will be based on the average of four consecutive values instead of the maximum value obtained.

iv) Radioactive substance parameters

The results presented should demonstrate that the local regulations, Guidelines for Canadian Drinking Water Quality, World Health Organizations standards, or other generally accepted thresholds, will be met at all times.

v) Turbidity parameters

The results presented should demonstrate that the local regulations, Guidelines for Canadian Drinking Water Quality, World Health Organizations standards, or other generally accepted thresholds, will be met at all times.

5.5.3 SAMPLING AND SAMPLE PRESERVATION

The sampling, preservation and transport of samples must meet the requirements described in the local regulations, the Guidelines for Canadian Drinking Water Quality or given by the accredited laboratory for the targeted parameters, whichever is more stringent.

5.6 EVENT REGISTRY

The testing organization must prepare a register of the conditions in effect during sampling, of the sequence of events and the interventions made on the treatment installation. In particular, it must note and report the following:

- the nature and quantity of products added (chemicals or other additives) and the frequency of the addition of these products during the entire test period;
- all notable events (equipment breakdowns, repairs, adjustments or minor modifications made to the system, declogging, scarification, or replacement of filtering material, etc.);

- the description of any intervention conducted on the facilities subject to a monitoring and analysis of these interventions with regard to the design, operation, inspection and maintenance of the technology (for example, if an intervention of a specialist was necessary, specify if the intervention is specified in the operation, inspection and maintenance guide provided by the applicant);
- the quantity and characterization, if applicable, of wastewater or sludge produced.

5.7 CHANGES DURING OPERATION

No significant modification is to be made to the technology during testing. If such a change is made, the testing must continue for at least 12 months after the modification.

5.8 CONTENTS OF THE TEST REPORT

The test report should be prepared by the testing organization and must be signed by an engineer with a description of his/her mandate.

The test report should include the following items:

- Evidence that the samples were taken by a qualified individual and that the applicable standards on sampling and preservation methods have been complied with;
- Presentation of all compiled analytical results (including laboratory analysis certificates in appendix). The calculation of expected maximum limits for water produced must have been performed with the obtained results (see Chapter 5.5);
- The operating conditions in effect before and during sampling;
- The type and quantity of additives used (coagulants, flocculents, oxidants or other additives), as well as their frequency of use during the entire test period;
- A description of all noteworthy events that occurred during the test period (equipment failure, repairs, adjustments, minor changes made to the system or other);
- An interpretation of the impact of action taken, operating parameters and events observed during testing on the results obtained
- Records and comments.

Table 2.1: Parameters and sample frequency for monitoring of surface water treatment[9]

PARAMETERS	RAW WATER	TREATED WATER
	Number of samples	**Number of samples**
pH (on site)	**28 (8 months + 4 weeks x 5 samples)**	**28**
Temperature (on site)	**28**	**28**
Fecal coliforms	**28**	**28**
Total coliforms	**28**	**28**
Heterotrophic plate count (HPC)	**28**	**28**
True colour (on site)	**28**	**28**
Total organic carbon (see note 1)	**28**	**28**
Turbidity	**28**	**28**
UV Absorbance at 254 nm (see note 1)	**28**	**28**
Ammoniacal nitrogen	**28**	**If required**
Nitrites	**12 (8 months + 4 weeks x 1 sample)**	**If required**
Nitrates and nitrites	**12**	**If required**
Chlorine demand (see note 2)	**N/A**	**12**
Total Alkalinity	**12**	**12**
Al (for technologies using aluminum salts)	**12**	**12**
Calcium	**12**	**6 (2 months + 4 weeks x 1 sample)**
Hardness	**12**	**6**
Iron	**28**	**28**
Manganese	**28**	**28**
Silt Density Index (SDI, see note 3)	**12**	**N/A**
Dissolved solids	**12**	**12**
Total solids	**12**	**12**
Conductivity	**28**	**28**
Trihalomethanes formation simulation (SDS-THM, see note 2)	**N/A**	**12**
Haloacetic acids formation simulation (SDS-HAA, see note 2)	**N/A**	**12**

Note 1: These samples allow the specific UV absorbance (SUVA) of raw water to be calculated.
Note 2: 24 hour test with 0.5 ± 0.2 mg/L of free residual chlorine after 24 hours, with a pH of 7.5 and a temperature of ± 22°C.
Note 3: This parameter need only be measured for technologies using nanofiltration. The samplings must be conducted upstream from the first membrane level, including re-circulation, if applicable.

[9] The SDI test method is based on ASTM D4189. All other parameters and sample frequencies are based on the standard set by the Quebec Drinking Water Treatment Technologies Committee in 2000.

Table 2.2: Parameters and sample frequency for monitoring of groundwater treatment[10]

PARAMETERS	RAW WATER	TREATED WATER
	Number of samples	Number of samples
pH (on site)	**13**	**13**
Temperature (on site)	**13**	**13**
Fecal coliforms	**26**	**26**
Total coliforms	**26**	**26**
Heterotrophic plate count (HPC)	**26**	**26**
True colour (on site)	**26**	**26**
Total organic carbon	**13**	**13**
Turbidity	**26**	**26**
Dissolved oxygen (on site)	**13**	**13**
Nitrates and nitrites	**13**	**13**
Chlorine demand (see note 1)	**N/A**	**13**
Total Alkalinity	**13**	**13**
Al (for technologies using aluminum salts)	**13**	**13**
Arsenic	**13**	**13**
Barium	**13**	**13**
Calcium	**26**	**26**
Hardness	**26**	**26**
Iron	**26**	**26**
Manganese	**26**	**26**
Silt Density Index (SDI, see note 2)	**13**	**N/A**
Sulfates	**13**	**13**
Sodium	**13**	**13**
Chlorides	**13**	**13**
Sulphides	**13**	**13**
Fluorides	**13**	**13**
Dissolved solids	**13**	**13**
Total solids	**13**	**13**
Conductivity	**26**	**26**
Reduction-oxidation potential	**26**	**26**
Trihalomethanes formation simulation (SDS-THM, see note 1)	**N/A**	**13**
Haloacetic acids formation simulation (SDS-HAA, see note 1)	**N/A**	**13**

Note 1: 24 hour test with 0.5 ± 0.2 mg/L of free residual chlorine after 24 hours, with a pH of 7.5 and a temperature of ± 22°C.
Note 2: This parameter need only be measured for technologies using nanofiltration. The samplings must be conducted upstream from the first membrane level, including re-circulation, if applicable.

[10] Parameters and sample frequencies are based on the standard set by the Quebec Drinking Water Treatment Technologies Committee in 2000.

6. TECHNOLOGY PERFORMANCE VERIFICATION

6.1 VERIFICATION REQUIREMENTS

A test report, signed by a professional engineer, accompanied by a technology fact sheet, may be prepared when a technology presents test data for the technology that demonstrates sufficient treatment efficiency and operational reliability.

The test protocol is described in Chapter 5. This testing must be conducted by a third party and the laboratory analyses must be carried out by a laboratory accredited in accordance with the ISO/CEI 17025 international standard, by a subscriber to the International Laboratory Accreditation Cooperation's (ILAC) Mutual Recognition Agreement (MRA), or by an equivalent accreditation organization (e.g. *Centre d'expertise en analyse environnementale du Québec*.)[11]

The Guidelines for Canadian Drinking Water Quality, or specific standards in local regulation if they are more stringent[12], should be respected during the test period.

6.2 TEST REPORT

In order for the performance of a technology to be verified for given conditions (flows, flow variations, nature of raw waters, etc.) the applicant must submit the following documents as supporting material for the file:

- the test report approved and signed by an engineer in compliance with Appendix A, including information pertaining to the integrity measurement method, if this acknowledgement is requested by the applicant, in compliance with Appendix C;
- third party declaration of independence;
- statement that the applicant holds the technology's commercialization rights.

[11] For the purposes of reciprocity with Québec, the Canadian ETV Program will accept testing and analyses carried out by laboratories accredited by *le Centre d'expertise en analyse environnementale du Québec* (CEAEQ), which is considered to be equivalent to ISO 17025.

[12] Regulation is province specific and some provincial standards may be more stringent than the Guidelines for Canadian Drinking Water Quality. Users are advised to consult the appropriate provincial standards.

APPENDIX A

TEST REPORT

APPENDIX A: TEST REPORT

A.1 TEST REPORT CONTENT

The test report must be divided into eight chapters containing the following items, at a minimum:

CHAPTER 1 —DESCRIPTION OF THE TECHNOLOGY

- Include the name, brand and model number.
- Explain the technology's theory of operation.
- Describe the treatment chain, if applicable.
- Describe each of the components of the technology and indicate its function.
- Describe the specifications relating to the pre-treatment steps.

When the proposed technology is based on a conventional technology to which the applicant wishes to incorporate new elements, the following information must be presented at the beginning of the chapter:

- the name of the conventional technology;
- the design criteria of the conventional technology and associated bibliographical references;
- a comparison between the proposed technology's design criteria and those of the conventional technology;
- an assessment of the potential impacts of these differences on the system's functioning or performance;
- a comparative analysis between the recommended pre-treatment for the proposed technology and the usual pre-treatment with the conventional technology.

CHAPTER 2 — OPERATIONAL LIMITS AND PRE-TREATEMENT

- Specify the range of flow in which the technology or each model of technology is usable.
- Specify the range of concentrations for each parameter deemed critical for the proper functioning of the technology, within the targeted application.
- Indicate any other technology usage constraint (excessive turbidity, presence of significant organic matter, etc.).
- If the technology requires a pre-treatment step, provide specifications relating to this pre-treatment or specific references in the applicable technical manual.
- Specify, if applicable, whether or not design adjustments are necessary, particularly to take into account the drop in water temperature in winter conditions and the reduction in the efficiency of equipment over time.

CHAPTER 3 — TECHNICAL SPECIFICATIONS AND DESIGN CRITERIA

- Provide technical specifications of each component that is likely to have an impact on the technology's performance.
- Specify the proposed design criteria, the redundant equipment, emergency measures, continuous measurements, alarms, etc.
- Provide capacity of the mechanical equipment
- If the size of the treatment unit is based on a kinetic or other mathematical model, provide this model as well as the coefficient values used.
- Include, if applicable, the diagrams or charts on which the treatment unit size is based, as well as any validation studies.
- If necessary, provide the scaling rules as well as the prescribed design and functional application limits.

CHAPTER 4 — EXPECTED PERFORMANCE

- Indicate the performance expected from the technology by specifying the raw water and treated water concentrations for each of the targeted control parameters.
- Present, where required, the models or curves used to predict the performance of the technology or equipment.

CHAPTER 5 — BY-PRODUCTS AND WASTEWATER TREATMENT

- Provide a list of by-products that could be formed during treatment and the expected concentrations. Specify, where applicable, the relationships between the quality of raw water, the product dosage, and the resulting by-product.
- Indicate the types of wastewater (sludge, filter backwash water, and other process water) that are produced during treatment and provide an estimate of the quantities to expect.

CHAPTER 6 — DESCRIPTION OF THE MONITORED INSTALLATION

- Provide contact information of the installation as well as a location plan.
- Provide detailed drawings and pictures of the installation subject to the performance monitoring.
- Provide specifications for each of the system components subject to the performance monitoring.
- Specify the technical characteristics and specifications.

CHAPTER 7 — INTERPRETATION OF RESULTS

- Indicate the flows and loads applied, as well as their variations.
- Compare the actual usage conditions to the design criteria (hydraulic load rate, retention time).

- Present the results observed during the continuous operation period specified in Chapter 5, in relation to the water intake and treated quality that allow design criteria to be specified, such as hydraulic and mass load rates applied to the system during testing.
- Also provide mass balance studies and all available results relating to the production and evacuation of wastewater and sludge.
- Compare the results obtained to the expected performance (verify the match with mathematical models or the curves used, where applicable).
- Assess whether or not the performance should continue beyond the test period.
- Also assess potential for sludge accumulation, progressive clogging of material, corrosion of equipment, etc., and its impact on system performance and functioning.
- Present, using a figure, the performance results as a function of the variable that correlates to the design or operational parameters, by indicating regression confidence intervals and tolerance limits;
- Include the list of authorized facilities, including the commissioning dates, as well as, if possible, the results of the control monitoring conducted up to 60 days before the date of submission of the monitoring report of the installation for which there was a monitoring (see Appendix B).
- Provide any other information useful for the interpretation of results.

CHAPTER 8 — <u>OPERATIONAL GUIDE AND RECOMMENDATIONS</u>

- Provide a user guide in which the recommended operation, inspection, and maintenance activities are specified by the applicant.
- Specify the recommended maintenance frequency in the case of periodic, fixed frequency activities or indicate the criterion requiring an intervention (volume or height of accumulated sludge in a basin, accumulation of water on a filter surface or other).
- Mention in the report any intervention conducted on the authorized facilities (e.g. if the intervention of a specialist was necessary, specify whether or not the operation manual sets forth such an intervention).
- Provide evidence that the usage, inspection, and maintenance recommendations contained in the operational guide or manual follow best practices, aim to allow the expected performance to be maintained, and are in agreement with the operational activities conducted during equipment testing.

A.2 ENGINEER'S SIGNATURE

The test report must be signed by an engineer who is a member of the Association of Professional Engineers in the Province or State of practice.

APPENDIX B

STATISTICAL ANALYSIS OF RESULTS OBTAINED

APPENDIX B: STATISTICAL ANALYSIS OF RESULTS OBTAINED

B.1 Calculation of expected maximum limits for the water produced

Following a generally recognized and accepted principle, justification of the performance presented in the test report should be based on a statistical analysis of the test results, in order to verify at a 95% confidence level that the technology performance data supports the technology performance claim.

The General Verification Protocol requires that the files submitted be supported by a statistical analysis of the results presented. The applicant may refer to the document entitled Environmental Technology Verification — General Verification Protocol (GVP) — Review of Application and Assessment of Technology (also available in French as *Vérification des technologies environnementales – Protocole de vérification générique (PVG) – Examen de la demande et évaluation de la technologie*) and its Appendixes, available on the ETV Canada website at [http://etvcanada.ca/home/protocols-and-procedures/].

B.2 Statistical analysis of results obtained

For all these parameters, a statistical method must be used in order to demonstrate that the results obtained will allow requirements to be met. The statistical analysis of the results must demonstrate that the performance claim has a statistical significance of 95%.

In order to conduct this statistical analysis, the applicant should use the guidance presented in chapter 5 of the document Environmental Technology Verification - General Verification Protocol (GVP) - Review of Application and Assessment of Technology and its Appendixes, available on ETV Canada's website [http://etvcanada.ca/en/home/protocols-and-procedures/].

APPENDIX C

METHODS FOR ESTABLISHING MICROORGANISM LOG REMOVAL CREDITS

APPENDIX C: METHODS FOR ESTABLISHING MICROORGANISM LOG REMOVAL CREDITS

The different methods accepted for establishing microorganism log removal credits are presented in this Appendix.

C.1 ULTRAVIOLET REACTORS

The performance of any ultraviolet irradiation disinfection reactor used in the treatment of water to be used for human consumption must have been tested by a recognized biological dosimetry method. The objective of the test is to confirm the effective dosage provided by an ultraviolet reactor in different operating conditions, while allowing the sensors to be calibrated based on the effective dosage provided.

Given the fact that there are several standards, the applicant must provide the test results, indicating the test protocol used and the independent organization that supervised the tests. The German (DVGM-W294), Austrian (ONORM M 5873-1) or American (NWRI-AWWARF and NSF 55) test protocols are currently references relating to the subject matter. The 2003 edition of the USEPA (UVGM), 2003 to 2006 edition under revision, or the new edition from November 2006, could also be used to validate the performance of an ultraviolet reactor.

If biological dosimetry tests are done directly in the location where the reactor will be installed, the protocol used shall comply with the test plan.

In all instances, the applicant shall submit, with the biological dosimetry report on tests conducted by an independent third party following a recognized protocol, a signed report by an engineer explicitly presented with spreadsheets, including the formulas and all relevant notes, the proof of every value to be presented in the Technology Fact Sheet regarding the reactor.

C.2 OTHER TREATMENT SYSTEMS

The maximum credit granted for treatment systems is the lowest value among the following two values:

- the lowest removal (log) obtained during tests allowing the removal credits to be established;
- the highest removal (log) verified by the periodic measurement of system integrity.

C.2.1 Protocol for establishing parasite and virus log removal credits

A recognized protocol allowing log removal credits to be granted to treatment systems is the EPA/NSF ETV protocol entitled *Protocol for Equipment Verification Testing for Physical Removal of Microbiological and Particulate Contaminants*, 2005 edition.

This protocol promotes the use of reference particles or microorganisms to check the manufacturing and assembly quality of systems with respect to parasite and virus removal. In compliance with this protocol, the test plan should meet the following guiding principles:

- the **reference** particles used (inert particles, microorganisms or other) are **representative** of the targeted organisms (parasites or viruses) and are easily **measurable or countable** (for example, by using sporulating aerobic bacteria, MS2 bacteriophagic viruses, fluorescent calibrated particles, etc.);
- the **reference particles** used are **sufficient in number** in order for it to be possible to establish a log removal level of the tested system;
- the **tested system** is **representative of the actual system**, for example, it uses the same type of membranes, operating conditions (membrane flux, water quality before membranes, flow conditions), assembly methods and accessories, housings, etc.

Any other approach on log removal credit may be recognized, on the condition that it clearly shows the disinfection performances achieved.

Therefore, the test plan **must be accompanied** by an integrity measurement method protocol for the treatment system submitted (see the following section).

C.2.2 Protocol to recognize an integrity measurement method

By conducting an integrity measurement (continuously or discontinuously) with an acknowledged method (direct or indirect measure), this protocol aims to ensure that the parasite and virus log removal credits of the technology under review are maintained. Even though several methods on the market exist for measuring equipment integrity, for the time being, there is no protocol that allows an integrity measurement method to be associated with the log removal credits granted.

However, the guiding principles that allow for the recognition of an integrity measurement method are the following:

- The **direct measurement methods** of integrity **are preferred** over the indirect methods (the table that follows presents certain methods as well as their benefits and drawbacks).

INTEGRITY MEASUREMENT METHODS		
INDIRECT METHODS	**BENEFITS**	**DRAWBACKS**
Permeate turbidity measurement	- Easy to use - Inexpensive	- Less precise than the following two methods
Particle monitoring in the permeate	- More precise than turbidity measurements	- More expensive than turbidity measurements
Particle counting in the permeate	- Very precise	- More costly than the two preceding methods - More complex than turbidity measurements
DIRECT METHODS	**BENEFITS**	**DRAWBACKS**
Maintaining pressure[1]	- Simple - Can easily be automated	- Filtration must be stopped - Must be incorporated in the process
Maintaining vacuum [2, 3]		
Bubble point measurement[1]	- Simple - Determines the size of defects in membranes	- Filtration must be stopped - Manual measurement, one module at a time - Difficult to implement on a large scale
Acoustic detection[1]	- Online control	- Need to control background noise

1. Used mostly for hollow fibre membrane modules.
2. Used mostly for spiralwound membrane modules.
3. Existing standard: ASTM D3923-94 (1998), *Standard Practices for Detecting Leaks in Reverse Osmosis Devices*.

- The **method used** for the system under review must be **tested at the same time** as the parasite and virus **log removal credits** are established.

- The **method used** must be sufficiently precise to detect a **quality variation in the water treated** that would risk having an impact on the log removal credits obtained by the system under review (for example, if the system under review is granted five log removal, the integrity measurement method must allow the distinction to be made between five log removal and four log removal).

It is therefore the responsibility of each applicant to establish a protocol as part of the test plan. This protocol **must be accompanied** by the parasite and virus removal credit establishment protocol (see preceding section).

APPENDIX D

COMPLEMENTARY TESTING REQUIRED IN CERTAIN SITUATIONS

APPENDIX D: COMPLEMENTARY TESTING REQUIRED FOR CERTAIN TECHNOLOGIES

This Appendix illustrates the complementary testing required for certain technologies

D.1 OPERATIONAL TESTING OF UV REACTORS

The applicant must provide test data on at least one existing UV system having worked for **a minimum of 12 consecutive months**. An independent organization is to have collected this data. The test conditions, i.e. water temperatures in the test location, must be recorded.

The following table[13] presents the parameters and frequency of measurement required for verifying the performance and operational reliability of an ultraviolet irradiation disinfection system.

PARAMETERS	FREQUENCY
Operating conditions	
Flow	Monthly average
Operational dose for reactor	Ongoing
Temperature	Monthly average (at least one measure per week)
Cumulative number of starts and stops	For one operating year
Number of lamps, sleeves, intensity sensors and ballasts replaced	For one operating year
Age of lamps (in hours)	Monthly average of the reactors in operation Total age of each reactor
Cleaning frequency (if applicable)	Number per month
Cumulative power consumed	Monthly value
Alarm monitoring	
List of low dose alarms	For one operating year
List of grounding alarms	
List of operating shutdowns	

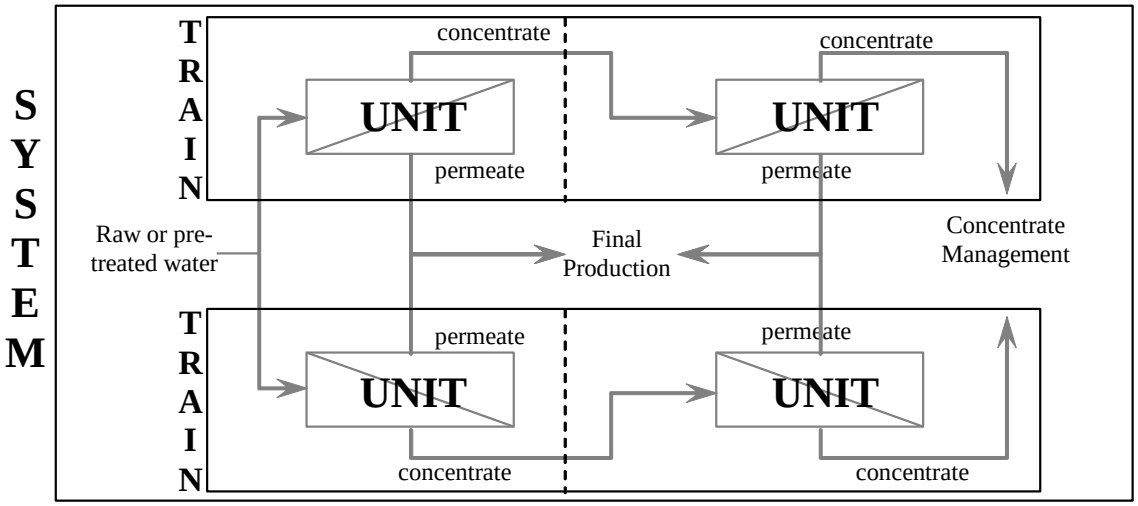
[13] Based on the standard set by the Quebec Drinking Water Treatment Technologies Committee in 2000.

D.2 PROJECTS INVOLVING MEMBRANES

D.2.1 EQUIPMENT CONTROL AND MONITORING

The main terms used in the equipment control and monitoring are illustrated in Figure 1.[14]

Figure 1 - Schematic representation of a membrane treatment installation



Membrane: A very thin layer of matter that allows separation to be done on a microscopic scale.

Module: A method of implementing membranes (spiralwound, tubular, hollow fibres, frame plate, etc.). This is the basic component in membrane treatment systems.

Housing: A container that is usually pressurized, in which one or several modules are found.

Unit: A method of arranging modules in the space given. In a unit, the modules may be in parallel, in series or both (for example, 10 rows in parallel consisting of three modules in series).

Train: An independent group of membrane treatment systems. Each train may contain one single unit or several units with associated pumps.

System: A complete treatment set including pre-treatments, trains (one or several in parallel) as well as post treatments.

D.2.2 EQUIPMENT AND MONITORING

For efficient operation of the treatment systems by membrane filtration, some pieces of equipment are essential, such as isolation valves for each unit and pump (maintenance) or even the interconnecting piping between pumps and units (any pump may feed any membrane train). Some parts are also necessary for module integrity measurement and verification.

[14] Based on the standard set by the Quebec Drinking Water Treatment Technologies Committee in 2000.

The following table[15] presents a list of necessary equipment in a membrane treatment installation for technology testing:

Equipment type	Parameters to monitor	Frequency
Sampling	Raw water quality	See Appendix B
	Treated water quality	See Appendix B
Temperature sensor	Treated water temperature	Ongoing
Pressure sensor	Pressure in the pre-treatment entry	Ongoing
	Pressure differential in pre-treatments	Ongoing
	Pressure at the entry of each unit	Ongoing
	Pressure at the exit of each unit (permeate and concentrate)	Ongoing
Flow meter	Raw water flow (or pretreated) at the entry of each train	Ongoing
	Permeate flow at the exit of each unit	Ongoing
	Concentrate flow at the exit of each unit	Ongoing
Turbidity reader (precise to one hundredth of a NTU*)	Permeate turbidity of each train	Ongoing
Integrity measurement	Membrane integrity	According to Test Plan

*Nephelometric Turbidity Unit

The following table[15] presents a list of parameters to monitor in order to conduct a better test of the modules as well as to optimize treatment performance:

Equipment type	Parameters to monitor
Sampling	Permeate quality (each unit)*
	Concentrate quality (each unit)*
	Backwash water quality (each unit)*
Head loss measurement	For every pre-treatment
	For each membrane unit
Flowmeter	Raw water flow pumped towards plant
Permeability measurement	Initial module permeability (ideally for each module) measured with very clean water[16] in controlled conditions (reference measurement)
	Permeability of each unit during operation
Measurement of the recovery rate	The overall rate, taking into account internal losses (membrane cleaning, pre-treatments, leaks, etc.)
Rinsing-cleaning	Number, frequency, duration and products used in pre-treatment rinsing and cleaning
	Pre-treatment replacement frequency
	Factor that triggers membrane cleaning
	Number, frequency, duration and products used in membrane rinsing and cleaning

* See the list of parameters in Appendix B.

[15] Based on the standard set by the Quebec Drinking Water Treatment Technologies Committee in 2000.

[16] Very clean water is water having a turbidity of less than 0.1 NTU, a conductivity of less than 50 µS/cm and a total organic carbon content of less than 0.2 mg/L.

ALARMS

Treatment processes by membrane filtration must provide for alarms in the following situations:

- non-compliance for integrity of a membrane train;
- a loss of permeability greater than the process control value;
- a pre-treatment head loss greater than the process control threshold;
- a membrane filtration head loss greater than the process control threshold;
- a turbidity greater than or equal to 0.1 NTU at a unit permeate;
- the pressure at the entry of a train unit greater than the process control threshold;
- a system shutdown due to a power outage (with a connection to the emergency generator in order to maintain drinking water production);
- flows (raw water, concentrate or permeate) greater than the process control thresholds.