PERFORMANCE VALIDATION PROCEDURE FOR DOMESTIC WASTEWATER TREATMENT TECHNOLOGIES

March 2021

Québec

Date	Modifications
2002	Publication of the first edition in Appendix 7 of the *Guide de présentation des demandes d'autorisation*
April 2008	General revision (First edition of the complete procedure)
December 2008	Addition of process equipment
February 2009	Addition of NH_4^+ reduction and statistical method
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July 2014	Addition of references and bibliography
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EDITORIAL TEAM

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PERFORMANCE VALIDATION PROCEDURE FOR DOMESTIC WASTEWATER TREATMENT TECHNOLOGIES

1. BACKGROUND

Generally speaking, specialized works on wastewater treatment set out commonly accepted, widely used and well-known rules for designing equipment. However, new technologies are sparsely covered in currently available publications, in spite of the fact that new technologies offer interesting potential solutions for domestic wastewater treatment. Technical fact sheets (hereinafter “fact sheets” or simply “sheets”) are therefore used to document the performance of such treatment technologies.

This publication sets out the mandatory procedure to be used for validating the performance of domestic wastewater treatment technologies for the purpose of publishing new fact sheets on the BNQ website. The sheets detail the test facility, design criteria and measured performance. The conditions under which a test is carried out should be close to the expected treatment technology design criteria as provided by the supplier of the equipment. This means that special attention must be given to the characteristics and flow values of incoming wastewater and the characteristics of the treatment unit that is being tested. Intermediary analysis and measurement for a given equipment procedure train will provide more specific knowledge about its performance and/or utilization.

The current edition of this publication mainly applies to new fact sheets, while providing details on the process for renewing or modifying an existing technical fact sheet.

2. PURPOSE

This publication describes the technical steps required to comply with the BNQ 9922-200 administrative procedural guide entitled *Drinking Water and Domestic Wastewater Treatment Technologies – Performance Validation – Administrative Procedure*. The publication sets out the technical and administrative measures applied by the BNQ when validating the performance of domestic wastewater treatment technologies or dosage equipment.

Technical fact sheets are meant to raise the level of user knowledge (engineering consultant, municipal and governmental technical staff, etc.) about new technologies and dosage equipment.

Performance validation testing applies to wastewater treatment systems that are not mentioned in the *Guide pour l'étude des technologies conventionnelles de traitement des eaux usées d'origine domestique* or that are used to explain particular features of the given systems that cause them to have different performance. Only one *Under Validation* and/or *Validated* sheet will be issued per applicant (equipment supplier) on a given subject. Moreover, validation can also apply to dosage equipment that operators may not be able to easily and quickly verify under real conditions.

In the Québec context, fact sheets are used for domestic wastewater treatment systems with flow greater than 3,240 L/d[1]. This type of water may originate from an isolated dwelling, a business, an institution or a community. Despite common features, this type of domestic wastewater may in fact have substantial differences from one case to the next. Those in charge of planning tests and fact sheet users should take this into account.

Performance validation procedure takes the following into account:

- Development phase (prototype, full-scale treatment system)
- Complete analysis such as parameters, frequency and period
- Wastewater temperature (< 10°C or ≥ 10°C).

The validation of performance tests makes it possible to publish the following types of fact sheets:

- *Under Validation* or *Validated*
- Field of application:
  - *"Commercial and institutional"*
  - *"Commercial, institutional and community"*

[1] l/d = litre per day

3. DEFINITIONS

In addition to the definitions set out in BNQ 9922-200 and BNQ 9922-201, the following terms apply for use in this publication.

Dosage equipment – Full-size equipment used to predetermine the quantity of a chemical reagent such as Al^{3+} or energy such as mW/cm^2. Those types of dosage equipment cannot be quickly verified by an operator in the field (ex. average ultraviolet radiation in a closed chamber). Validation monitoring in this circumstance may be equipment specific. However, if the dosage equipment is part of an equipment train, it is deemed the equivalent of processing equipment. Consequently, the description and operational mode of dosage equipment with affluent and effluent equipment train monitoring is acceptable.

ADL-3, ADL-6, ADL-12 – Maximum average discharge corresponding to upper prediction interval limit averages calculated for three, six and twelve results.

Processing equipment – Full-size equipment used for the partial treatment of wastewater, such as nitrification.

Prototype – Model with all of the technical qualities and operational characteristics of the marketed treatment technology.

Sampling program – Package that includes the mode of sampling and sample conservation measures, sampling dates and/or sequences, as well as the list of the parameters to be analyzed, the location of withdrawals and the identity of the accredited test laboratory.

Test plan – Document that defines the goal, concept, methodology, applicable conditions and testing steps, including the sampling program.

Third party – Entity at arm's length from the applicant (a distributor, supplier or manufacturer). The independent third party must be a member of a professional order or a firm where at least one person is a member of a professional order. The professional must possess the knowledge required to monitor wastewater treatment and sign the report(s) that are submitted.

Treatment system – Treatment prototype or technology.

Treatment technology – Processing equipment or marketable full-sized equipment train. Process equipment trains are treated as a whole in fact sheets where no intermediary evaluation has occurred.

4. VALIDATION PERFORMANCE TEST PROCEDURE

Table 4.1 summarizes the validation procedure for receiving a new fact sheet or an amendment to an existing technical fact sheet. ***Under Validation*** **fact sheets are not prerequisites for obtaining** ***Validated*** **sheets.**

TABLE 4.1 – VALIDATION PROCEDURE SUMMARY

APPLICATION FOR PUBLICATION OF AN *UNDER VALIDATION* FACT SHEET	
Facility	• Prototype • Treatment technology
Performance test duration	• Minimum 13 consecutive week or deemed consecutive week monitoring.
Documentation to be produced by the applicant following the performance tests	• Backup required per BNQ 9922-200 • Engineering report per Appendix 1 herein • Test report including test results per Appendix 2 herein
BNQ documents	• Comments on the test plan if an application is submitted to the BNQ • As appropriate, the published an UNDER *VALIDATION* fact sheet
APPLICATION FOR PUBLICATION OF A *VALIDATED* FACT SHEET(1)	
Facility	• Treatment technology • Dosage equipment if not part of a treatment train
Duration of the performance test	• Treatment technology: Minimum 52 consecutive or deemed consecutive week monitoring • Dosage equipment: monitoring per Appendix 3B herein
Documentation to be produced by the applicant following the performance tests	• Backup required per BNQ 9922-200 • Engineering report per Appendix 1 herein • Third-party test report on – Treatment technology, per Appendix 3A herein – Dosage equipment, per Appendix 3B herein
BNQ documents	• Treatment technology: – Comments on the test plan if an application is submitted to the BNQ • Dosage equipment: – Comments on the test plan if an application is submitted to the BNQ – Production of a new test plan if needed • If appropriate, the published *VALIDATED* fact sheet

(1) If Appendix 3B does not include a test plan for the dosage equipment to be validated that is separate from an equipment train, the manufacturer or applicant is required to prepare one and submit it for analysis by the BNQ. If appropriate, the test plan (revised if need be) will be added to the third procedure in Appendix 3B.

4.1 Fields of application

Table 4.2 shows various situations that make it possible to determine the fields of application during the process of validating a fact sheet. It also mentions a cold water temperature constraint that applies to the *community* field.

Commercial and institutional
This field of application relates to facilities that deal with domestic wastewater where temperature is equal to or greater than 10°C. This field of application targets facilities that are not connected to a wastewater collection system, such as restaurants or highway rest areas or that serve a collection system that operates in summer, such as a camping ground.

Commercial, institutional and community
The *community* field of application relates to all wastewater treatment facilities that are part of a collection system serving two or more buildings and where there is a probability of low temperature (< 10°C) episodes over a lengthy period of time. The *Community* field of application also includes the *Commercial and institutional* field.

Table 4.2 — Influence of the test situation on the field of application

Wastewater situations during the test	**Field of application for a fact sheet to be published** (1)	
	Under Validation	***Validated***
	• Prototype • Treatment technology	Treatment technology
Wastewater not from a sewage system or Wastewater from a sewage system whose temperature has not fallen below 10°C for at least 10 deemed consecutive weeks	*Commercial, institutional (and community)*(2)	*Commercial and institutional*
Wastewater from a sewage system whose temperature was less than 10°C for at least 10 deemed consecutive weeks	*Commercial, institutional and community*	*Commercial, institutional and community*
		Dosage equipment
Per Appendix 3B	*N.A.*	*Commercial, institutional (and community)*(3)

(1) Whenever applicable, different ADL-3 and ADL-6 values may be recognized if their average monitoring data are statistically different on the basis of temperature.
(2) An *Under Validation* "Community" fact sheet may be issued despite insufficiently lengthy cold water (< 10°C) testing, on the basis of third-party scientific references such as a scientific article, recognized design work, etc.
(3) The effect of cold water (< 10°C) must be tested on the dosage equipment in order for the "Community" field to be included in a *Validated* fact sheet.

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4.2 Equivalent validation tests

4.2.1 Modular equipment – NQ 3680-910 and/or CAN/BNQ 3680-600 certification

As stipulated in its *Guide de présentation d'une demande d'autorisation pour réaliser un projet assujetti à l'article 32 de la Loi sur la qualité de l'environnement*, the MELCC recognizes modular domestic wastewater technology for treatment performance that is certified under NQ 3680-910 and CAN/BNQ 3680-600 for commercial and institutional projects.

Recognition of community projects would be based on at least 10 deemed consecutive weeks of testing at less than 10°C at the entrance of the modular equipment during the certification test. Applications for MELCC authorization of these types of projects should include temperature monitoring data during the certification testing period.

Consequently, no fact sheet is required if the implementation conditions of each piece of equipment installed in parallel complies with its certificate. It is worth recalling that MELCC validation recognition is linked to certification oversight, including the concentration range of wastewater treated during the certification tests.

4.2.2 Scalable technologies – NQ 3680-910 and CAN/BNQ 3680-600 certification

The BNQ accepts applications for an *Under Validation* fact sheets based on the full-scale utilization of a single type of equipment where capacity exceeds certified values, by submitting the following:

- The NQ 3680-910 or CAN/BNQ 3680-600 certification test report
- An engineering report that includes the following information:
  - Justification for full-scale utilization, such as the criteria that were retained and/or added
  - Justification if the application is for the community field in spite of insufficient cold water (< 10°C) testing
  - Signature of an engineer who is a member of a professional order for validation of a fact sheet that includes ADL values
- All other backup documentation as detailed in the BNQ 9922-200 administrative procedure.

Once the proposed scale-up has been ruled on positively, an *Under Validation* sheet will be published.

4.2.3 Monitoring equivalency based on certification or an independent body

Third-party test reports that comply with the supporting documents requirement for fact sheet validation applications may be replaced by certification testing reports from a body that is accredited by the ISO, CCN, NSF or EN, or test reports issued by an independent body under an *Environmental Technology Verification* (ETV), Title 22 standard government program.

However, since ADL information is not detailed in the normative documents, this information is required when applying to the BNQ for a technical fact sheet. With respect to target ADL parameters, compliance with the number of results specified in Appendix 2 (Under Validation) or Appendix 3 (Validated*)* is required.

Applications to the BNQ for a fact sheet must include the supporting documentation enumerated in BNQ 9922-200. The proposed fact sheet included in the application must be recommended by an engineer who is a member of a professional order.

4.2.4 Technology in use elsewhere

Full-scale proven treatment technologies in use elsewhere in the world are not required to undergo performance test monitoring here if the available results are satisfactory. However, in order for an *Under Validation* or *Validated* technical fact sheet to be issued, monitoring data must meet the criteria defined in Appendix 2 or 3, respectively. An engineering report that includes monitoring data and a fact sheet proposal must be submitted to the BNQ along with the application. The fact sheet proposal must be recommended by an engineer who is a member of a professional order.

4.3 Test plan approval

Appendix 2 (Under Validation) and Appendix 3 (Validated) herein set out the monitoring that is required based on the level of certification that is sought.

Applicants may apply to the BNQ for approval of a test plan or sampling program based on the test plan itself.

If the monitoring level applied for herein or the one that is submitted to and accepted by the BNQ cannot be met during the tests, the applicant is required to contact the BNQ as soon as possible for its approval of the changes to be made, failing which the applicant could face denial of its new or amended technical sheet application.

5. FACT SHEET RENEWAL, AUDIT OR AMENDMENT

5.1 Renewal

Renewing *Under Validation* and *Validated* fact sheets is subject to the conditions set out in BNQ 9922-200. BNQ review of applications for renewal is used to approve the application when the conclusion is positive. Otherwise, the fact sheet will be withdrawn.

5.2 Audits

An audit may be called for where technology or dosage equipment performance deficiencies are presumed. The audit may recommend the status quo for the sheet, temporary or permanent withdrawal or limitations/constraints, the latter (such as media replacement at five-year intervals, annual sludge removal, etc.) to be added to the fact sheet.

5.3 Modifications

An engineering report per Appendix 1 must be submitted with all applications for a modification to an existing sheet (e.g., the same prototype under different conditions). Applications must also include a test report that is in compliance with Appendix 2 or 3, whichever applies.

The test report for an Appendix 2 *Under Validation* sheet will, however, not be required if the desired modification only concerns recognition of the community field of application (< 10°C). As set out in Table 4.2, this technical modification can be justified on the basis of scientific references.

For modifications of a strictly administrative nature, refer to BNQ 9922-200.

6. REFERENCES

In this publication, a dated normative reference specifies the actual version used, while a non-dated normative reference refers to the most recent version of the applicable reference.

For the purposes of this publication, the following reference works (including any modifications, errata, corrections, amendments, etc.) contain requirements that must be taken into account and that are quoted when appropriate:

BNQ (Bureau de normalisation du Québec) [www.bnq.qc.ca]

BNQ 9922-200	*Drinking-Water and Domestic-Wastewater Treatment Technologies – Performance Validation – Administrative Procedure*
BNQ 9922-201	*Drinking-Water and Domestic-Wastewater Treatment Technologies - External Experts' Skills Recognition for the Analysis of Requests for Performance Validation of Treatment Technologies*
NQ 3680-910	*Wastewater Treatment – Stand-Alone Wastewater Treatment Systems for Isolated Dwellings*
CAN/BNQ 3680-600	*Onsite Residential Wastewater Treatment Technologies*

ETV

Verification Protocol for Secondary Effluent and Water Reuse Disinfection Applications, Environmental Technology Verification Protocol, October 2002. United States Environmental Protection Agency (USEPA) Archive document
(https://archive.epa.gov/nrmrl/archive-etv/web/pdf/04_vp_waterreuse.pdf)

Environmental technology verification– Canada
(https://etvcanada.ca/home/verify-your-technology/)

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

ISO/IEC 17025:2005	*General Requirements for the Competence of Testing and Calibration Laboratories*
ISO 5667-10:2020	*Water quality — Sampling — Part 10: Guidance on sampling of waste water*
ISO 14034:2016	*Environmental Management/ Environmental Technology Verification (ETV)*

MELCC (Ministère de l'Environnement et de la Lutte contre les changements climatiques) [www.environnement.gouv.qc.ca]

Guide pour l'étude des technologies conventionnelles du traitement des eaux usées d'origine domestique
(https://www.environnement.gouv.qc.ca/eau/eaux-usees/domestique/index.htm)
Guide de présentation d'une demande d'autorisation pour réaliser un projet assujetti à l'article 32 de la Loi sur la qualité de l'environnement
(https://www.environnement.gouv.qc.ca/eau/demande-autorisation/article32/guide-explicatif.pdf)
Formulaire de demande d'autorisation pour réaliser un projet assujetti à l'article 32 de la Loi sur la qualité de l'environnement
(https://www.environnement.gouv.qc.ca/eau/demande-autorisation/article32/index.htm)
Guide d'échantillonnage à des fins d'analyses environnementales – Échantillonnage des rejets liquides
Cahier 1 – Généralités
(http://www.ceaeq.gouv.qc.ca/documents/publications/echantillonnage/generalitesC1.pdf)
Cahier 2 – Échantillonnage des rejets liquides
(http://www.ceaeq.gouv.qc.ca/documents/publications/echantillonnage/rejets_liquidesC2.pdf)
Modes de conservation pour l'échantillonnage des rejets liquides (eaux usées) – fascicule DR-09-04
(http://www.ceaeq.gouv.qc.ca/documents/publications/echantillonnage/dr09_04rl.pdf)

NSF (National Sanitation Foundation) [www.nsf.org]

NSF/ANSI 55	*Ultraviolet Microbiological Water Treatment Systems*, NSF International Standard/American National Standard

APPENDIX 1

ENGINEERING REPORT

APPENDIX 1: ENGINEERING REPORT

PREAMBLE

Applications to the BNQ for an *Under Validation* and *Validated* fact sheets or a technical amendment to an existing sheet must include an engineering report.

ENGINEERING REPORT CONTENT

The applicant's engineering report must be prepared and signed by an engineer who is a member of a professional order in their province or state of practice and may either be employed by the applicant or an arm's length third party.

The engineering report must be divided into seven chapters, based on the (included) technical fact sheet submitted for validation that in turn is based on empirical test data.

CHAPTER 1 – MANUFACTURER'S CONTACT INFORMATION

- Provide the name and contact information of the manufacturer and, if possible, the name, telephone number, e-mail address and fax number (if any) of a contact.
- If applicable, provide the name and contact information of the distributor, along with the name, telephone number, email address and fax number (if any) of a contact.

CHAPTER 2 – GENERAL INFORMATION

- Provide the name of the treatment system or dosage equipment, including the make and model number, if applicable.
- Explain the operational principle of the system or equipment.
- Describe the wastewater liquid train and, if applicable, the sludge train.
- Describe each of the component parts and their function(s).

NB This chapter is not to be used to extrapolate test results.

CHAPTER 3 – DESCRIPTION OF THE FACILITY DURING TESTING

Diagram of the facility

- Show the part that designates the treatment system or dosage equipment in a box (pretreatment may therefore be shown outside the box).
- As clearly as possible, illustrate the treatment system or dosage equipment.
- Show the affluent and effluent (and intermediate points, if any) sampling points in a detailed manner.

Location of the facility

- Provide the coordinates of the location.
- Include a site plan.
- Include detailed map(s) and photos of the facility.

Components and pretreatment

- Provide the specifications of each component parts of the treatment system or dosage equipment that was monitored for performance.
- Provide the pretreatment specifications, if applicable.

Test period

- State the duration of the test period.
- State the type and temperature of the raw sewage.

CHAPTER 4 – OPERATIONAL AND MAINTENANCE DESCRIPTION DURING THE TESTING PERIOD

- State the mode and frequency of affluent input and any flow variations.
- Describe the functioning of equipment and the operational levels.
- Describe the following action:
  - Start-up
  - Sludge evacuation procedures
  - Replacement of essential components
- Describe any stoppages due to a power failure or equipment breakdown.

CHAPTER 5 – PROCESSING PERFORMANCE DURING TESTING

- Provide the measured results (see Appendix 2 or 3, as applicable) of affluent and effluent quality during the continuous period of operation.
- State the flow, load and any variation thereof.
- Provide a design and/or operational parameter performance diagram.
- State the average ADL discharge limits for 3, 6 and 12 results (see Appendix 4) as well as the distribution types used for each parameter.
- Enumerate the by-products and types of residual water (sludge, washwater and other process water) formed during processing and state the management mode that was used. Provide a quantitative input-output statement and, if applicable, show the relationship between raw water quality, product dosage and the concentration of resulting by-products and residual waters.
- Provide any other information that could be useful in interpreting results. If the application is for a *Validated* sheet, include if applicable the monitoring data for each of the authorized *Under Validation* facilities. Those data should include the dates of entry into service and the results of control monitoring that took place prior to 60 days from the date when the test report was filed with the BNQ.
- If applicable, state any references to equivalent validation tests (see section 4.2 of the procedure).

CHAPTER 6 – DESIGN CRITERIA

Criteria derived only from the tests

- On the basis of purifying performance during testing, provide the design criteria such as applied or removed mass load, mixing ratio, hydraulic retention time and their maximum variation, if any.

- State the peak hourly and average flow values during the test period.
- As applicable, state and justify any differences between the facility that was monitored (such as a prototype) and the treatment technology or dosage equipment described in the fact sheet for marketing purposes.
- As applicable, provide the justification for full-scale use. Some aspects of full-scale use may not be theoretically justifiable and as such, further actual case testing or monitoring may be required.

Criteria derived from scientific references–Temperature – Under Validation

With respect to applications for *Under Validation* fact sheets, if cold water (< 10°C) testing was not conducted over a sufficient period of time, justification based on scientific references are acceptable. Any references provided, such as published Masters or Doctoral theses, scientific articles or manuals quoting recognized formulae such as the Arrhenius formula must have been evaluated for admissibility by a third party. The report must show the Internet hyperlinks or include photocopies of excerpts that support the proposed amendment(s).

CHAPTER 7 – FIELDS OF APPLICATION

- State the desired field of application for the fact sheet.
- If applicable, justify the choice of the community field of application.

TECHNICAL FACT SHEET PROPOSAL

The preparation of the technical fact sheet must be supported by information in the engineering and test report.

APPENDIX 2

PERFORMANCE MONITORING FOR AN UNDER VALIDATION FACT SHEET

APPENDIX 2

PERFORMANCE MONITORING FOR A UNDER VALIDATION FACT SHEET

PREAMBLE

The purpose of validation is to demonstrate the performance of a treatment system under specific test conditions.

This appendix details what is required to obtain an *Under Validation* fact sheet.

- Points A.2.1 to A.2.6 lay out the various aspects of a test plan, including the sampling program.
- Point A.2.7 explains the required contents of a test report.

The tests administered by a certification body or accredited audit entity and the corresponding report can be accepted by the BNQ under the conditions set out in section 4.2.

A.2.1 TEST PLAN

Applicants are required to prepare a test plan that follows the guidelines set out in this appendix while completing them in accordance with the special features of their treatment system, in line with the target applications. Applicants or their representatives may request approval of the test plan by the BNQ, while the treatment system itself may be operated by an applicant or its representative.

The technical information in the fact sheet will come from the tests, except for cold water temperature (< 10 °C) where reliance on scientific references is feasible for modifying criteria measured at a higher temperature (Table 4.2, note 2). As a consequence, the applicant and the engineer that signed the engineering report are responsible for ensuring that all conditions required for obtaining the desired fact sheet are taken into account during the tests, including:

- Treatment system, such as the height of the treatment system
- Treated water, for example, flow, concentration and temperature values
- Operational factors such as dissolved oxygen and mixing level.

In addition, the applicant and its engineer (as signatory of the engineering report) are responsible for ensuring that the operational monitoring and sampling program will make it possible to obtain all data and information required for an *Under Validation* sheet. A sheet may list more than one type of environmental monitoring for a single treatment system, leading to different design and performance criteria (such as different unit heights) for identical or modified systems. Applicants must contact the BNQ if it is desired that a fact sheet is to include more than three performance levels.

A.2.2 TEST SUPERVISION

A qualified professional possessing the knowledge needed for monitoring wastewater treatment need to supervise testing. The test monitoring can be under the supervision of the qualified professional or of another qualified professional. That professional may be employed by the applicant if a sampling program that includes the sampling dates and/or sequence from the first day of testing onward is filed with the BNQ prior to the start of the performance tests. If the sampling program is not filed with the BNQ, test monitoring must be performed by a third party (see definition above).

Test supervision must make it possible to objectively check the accuracy of the performed and reported tests. Moreover, all required investigations must be performed in order to determine operational conditions both prior to and during sampling. These conditions must be logged and addressed in the test report.

Supervision must include measurement readouts and sampling logs, as well as an event registry with a journal showing all operational parameters, sampling activity and a record of prevailing conditions during sampling.

The test report must include all compiled results, records and comments, analysis and interpretation of results related to the operating conditions and action taken, as well as hydraulic and mass balance on the treatment system. The test report must be written and signed by the qualified supervising professional.

A.2.3 OPERATIONAL MONITORING

During inspections, the following must be noted: system status, indications and recordings from measurement equipment and all other instrumentation including flowmeters and probes that measure temperature, dissolved oxygen, pH, liquid level and alarms… Device calibration must be checked and, when needed, tested for functionality. Robotic programming and calibration dates must be noted in the event registry.

The operational and stoppage times of equipment must also be noted. These include injection, transfer and recirculation pumps and, if applicable, operational speed, variator induction percentages and even the number of working cycles of stop-and-go equipment. As applicable, the following must also be noted: the volume of air injected into the reactors, the type, model, number and layout (dimensions, spacing, depth) of working aerators, as well as their operational mode (constant, intermittent (stop-and-go), variable with or without interruption) and specific rate such as cubic metres of air per hour (m^3air/h) per cubic tank metre; m^3air/h per square metre of surface of the tank, etc.

Event registry

The signatory of the test report is required to keep a registry of events and prevailing conditions during sampling, as well as a chronology of events and action taken on the treatment system, noting and reporting at least the following:

- The nature and quantity of products added (chemicals, nutrients, bacteria, enzymes, etc.) and the frequency of injection during the entire period of tests performed on the treatment system

- All noteworthy events, such as tuning, replacing a pump by another identical one, filtration material changes, and maintenance, including declogging and modifications. Point A.2.6 details the consequences that may be related to replacement and modification
- Water, sludge and other levels
- System, automate and instrumentation status
- Equipment calibration dates
- Treatment system sludge age, if applicable
- Dates pertaining to residue extraction, quantity of residue extracted and mode of extraction used.

A.2.4 SAMPLING PROGRAM

The sampling program, including the sampling dates or sequence starting on the first day of sampling must make it possible to determine the performance achieved by the treatment system under the test conditions. The sampling days listed in the sampling program must be uniformly distributed from the first to the final week of testing.

Sampling must be carried out when the treatment system is operating under stable conditions. A stable condition may be associated with performance or a state with no significant change over time and could include the 5-day concentration of carbonated biochemical oxygen demand ($CBOD_5$) effluent or biofilm development.

In the event that the details of the sampling program in this appendix do not match the target application, **the applicant or its representative may file a request with the BNQ for approval of their sampling program in the framework of an application to approve the test plan.**

A.2.4.1 Sampling process

Samples must be taken by a qualified individual per Cahier 1 – Généralités and Cahier 2 – Échantillonnage des rejets liquides of the *Guide d'échantillonnage à des fins d'analyses environnementales* issued by the Centre d'expertise en analyse environnementale du Québec (CEAEQ).

In the test report, the individual in charge of test supervision must certify that the samples were taken by one or more qualified individuals and that sampling norms were met.

A.2.4.2 Preservation of samples and analytical laboratories

Preservation and shipping
Sample preservation, shipping and storage must comply with paragraph 5.4 of ISO 5667-10:2020 and CEAEQ DR-09-04 (*Modes de conservation pour l'échantillonnage des rejets liquids - eaux usées)* and all directives issued by the accredited laboratory. In the test report, the individual in charge of supervising the treatment system tests must certify that sample preservation and shipping complied with appropriate conditions and timelines prior to laboratory delivery.

Sample test laboratories
Sample analysis must be performed by a CEAEQ-accredited or ISO/CEI 17025-compliant independent laboratory. The accreditation body must be signatory to the ILAC (International Laboratory Accreditation Cooperation) Mutual Recognition Arrangement (MRA).

A.2.4.3 Treatment stage parameters and sampling frequency

The sampling and analysis program must include at least 20 sampling days, and at least one sample per week. The monitoring period shall be at least 13 consecutive weeks covering a minimum of 85 days or 13 deemed consecutive weeks. This monitoring period allows for one or more disruptions related to a power outage or peripheral equipment breakdown (pumps, blowers, etc.). Nonetheless, each official monitoring segment must comprise periods of at least five consecutive weeks, for a total of at least 13 official weeks, as shown in the following example: 10 consecutive weeks + outage + 2 consecutive weeks + breakdown + 5 consecutive weeks. Flow and load values must be similar before and after the disruption. Subsequent to a disruption, a load build-up period may be required before restarting official monitoring.

A treatment system may perform a one-time stage such as $CBOD_5$ reduction or a combination of treatment stages such as the reduction of dissolved $CBOD_5$, total suspended solid (TSS), BOD_5, fecal coliforms, etc. A sampling program for a typical domestic wastewater treatment system must take account of the information relating to the treatment stages that is shown in Table A.2.1.

For treatment systems composed of a series of processing equipment units such as biological reactors, intermediate monitoring (not described in detail herein) would allow the applicant to show the performance of different portions of its treatment technology. As previously mentioned, the applicant or its representative may submit a request to the BNQ for approval of its sampling program in the framework of an application to approve its test plan prior to testing.

Table A.2.1: At least 13 weeks–parameters and number of analyses

NORMAL TREATMENT STAGE MIMIMUM PARAMETERS	MINIMUM NUMBER OF SAMPLING DAYS	
	BEFORE TREATMENT(1)	AFTER TREATMENT(1)
Dissolved $CBOD_5$ reduction		
$CBOD_5$	**20**	**20**
Dissolved $CBOD_5$	**20**	**20**
TSS	**20**	**20**
Temperature	**20**	**20**(2)
Dissolved oxygen(3)		**20**
$CBOD_5$ and TSS reduction		
$CBOD_5$	**20**	**20**
Dissolved $CBOD_5$	**20**	
TSS	**20**	**20**
Temperature	**20**	**20**(2)
pH		**20**
Dissolved oxygen(3)		**20**
Reduction of solids		
TSS	**20**	**20**
VSS	**20**	**20**
Temperature	**20**	
pH		**20**
Total phosphorous reduction (TP) (chemical coagulation)		
TP	**20**	**20**
pH		**20**
Alkalinity	**20**	
Fecal coliform reduction (FC) (disinfection)		
FC(4)	**20**	**20**
Ammonia reduction (NH_3-NH_4) (nitrification)		
Total Kjeldahl nitrogen (TKN)	**20**	
Ammoniacal nitrogen (NH_4^+)	**20**	**20**
Nitrites and nitrates (NO_2-NO_3)		**20**
pH		**20**
Alkalinity	**20**	

(1) The notions of before and after treatment refer to the treatment system that is subject to certification. Before and after treatment sampling is performed on the same day.

(2) To be added if effluent becomes the affluent of another part of the system whose individual performance values will be requested on the sheet.

(3) In or at the outlet of each reactor.

(4) Given the wide variability of fecal coliform results, a greater number of results is needed. Three one-time samples must be withdrawn at distinct times on each sampling day and separately analyzed [3 values per day x 20 days = 60 sample values)]. Samples withdrawn on the same day must be spaced out by at least two hours.

Complementary monitoring may be required to better document the quality of water to be treated or that was treated, as well as the by-products formed during the treatment process. As an indication, the analysis of iron and manganese, transmittance and treated water hardness may be relevant to any expected additional UV disinfection. A non-exhaustive list of analytical parameters that have not been previously enumerated includes COD (chemical oxygen demand), orthophosphates (o-PO_4), volatile suspended solids (VSS), calcium, volatile organic compounds (VOC), conductivity, aluminum, oils and greases, Langelier index, redox potential, total dissolved solids (TDS), sulphur and hydrogen sulphide (H_2S).

A.2.5 FLOW, CONCENTRATION AND LOAD

Flow

Average daily and maximum hourly flow values are shown on the fact sheet. The volume of water processed by the treatment system must be continuously measured by means of a flow totalizer or pump time recorder. If a pump time recorder is used, pump flow-through must be calibrated both before and after the test period. Cumulative daily volume readouts are required during testing.

For hourly peak flow validation, which is not the same as average daily flow, continuous flow monitoring must be hourly, or every six hours if flow is variable at that interval.

Average daily flow

For the purpose of certification, average daily flow shown on the fact sheet is the average of daily flow values measured during the entire test period.

Maximum hourly flow

When flow at the affluent of the treatment system is in continuous flow in receiving the totality of the sewer system (except for overflow), with or without pumping, the maximum hourly flow recorded in the fact sheet will be the average of maximum volumes recorded during 60 consecutive minutes on each day of the test period.

When the affluent flow of the system is controlled using pre-set values, a flow range between 50% and 200% of average flow is deemed representative of flow variations that are inherent to the functioning of a treatment facility. The flow variation must be induced on a daily basis in the following proportion:

- 25% of the time (six hours a day) at 50% or less of average flow
- 25% of the time (six hours a day) at 200% or more of average flow.

Variation can be controlled on the basis of sine or square waves. In such cases, the maximum daily flow recorded in the fact sheet will be the average of maximum volumes during 60 consecutive minutes on each day of the test period. When no hourly data is available, the peak hourly flow recorded in the fact sheet will be the hourly average of the maximum volumes processed during six-hour periods (25% of the time) on each day of testing.

If the treatment system is not fed by the totality of the sewer system and the instructions regarding flow variation 25% of the time at 50% or less of average flow

and 25% of the time at 200% of average flow are not followed, the maximum hourly flow will be deemed identical to the average daily flow on an hourly basis.

Average concentration
The average concentration recorded in the sheet is for the full testing period. It is calculated from the overall average of daily concentrations measured without considering flow.

Average load
The average load recorded in the sheet is for the full testing period. It is calculated from the daily load measured on each of the sampling days. Daily load is calculated by multiplying daily flow by daily concentration for each sampling day.

A.2.6 REPLACEMENT AND MODIFICATION DURING TESTING

Replacing a unit such as a pump or a valve by an identical or equivalent one is not considered to be a modification. Nonetheless, this kind of replacement made because of equipment fatigue or wear and tear must be recorded in the test report and on the fact sheet.

No modification should normally be made to the facility when testing a treatment system. However, if a change becomes required, treatment system test monitoring must comply with point A.2.4.

Notwithstanding the preceding, applications for a monitoring change or previously approved test plan per point A.2.4 can be submitted to the BNQ (see section 4.3).

A.2.7 CONTENTS OF THE TEST REPORT

The treatment system test report, which must list the prevailing operational conditions before and after sampling was performed, can be incorporated into the engineering report. Moreover, the report should comment on the effect on results of any intervention that occurred or operational conditions and events that were observed during testing. The test report must be signed by the individual that supervised the tests.

The test report must include, but not be limited, to the following:

- Operational conditions prevailing before and after sampling, including equipment and instrumentation control modes such as operational instructions
- Nature of added products such as coagulants, coagulant aids, oxidants or other additives, as well as their quantities and frequency of addition during the entire monitoring period
- Flow measurement procedures and the location of measurement and withdrawal points
- Method used for sampling and the mode used for sample preservation and shipping

- Certification that samples were taken by a knowledgeable qualified individual using sampling and preservation methodology standards such as are found in Booklets 1 and 2 of the *Guide d'échantillonnage à des fins d'analyses environnementales*)
- A description of all noteworthy events that occurred (equipment breakdown, repairs, replacement, tuning, changes to the treatment system, etc.)
- Interpretation of the effect on results of interventions, operational conditions and events observed during testing
- Presentation of all compiled analytical results (include the laboratory test certificates). All results, as well as ADL-3, ADL-6 and ADL-12 (see Appendix 4), should be submitted, as follows:
    - In tabular form, stating sampling dates and times (in the case of one-time sampling)
    - In graphic form, based on sampling dates or corresponding number of days
- Hydraulic and mass balance on the treatment system
- Reports and comments.

APPENDIX 3

PERFORMANCE MONITORING FOR A *VALIDATED* FACT SHEET

APPENDIX 3A

PERFORMANCE MONITORING FOR A VALIDATED FACT SHEET

TREATMENT TECHNOLOGIES

APPENDIX 3A

PERFORMANCE MONITORING FOR A VALIDATED FACT SHEET

TREATMENT TECHNOLOGIES

PREAMBLE

The purpose of performance monitoring validation is to demonstrate the stability of treatment technology over one year (four seasons) under the specific test conditions.

This appendix lays out what is required for a *Validated* technical fact sheet.

- Points A.3A.1 to A.3A.6 state a number of test plan aspects, including the sampling program.
- Point A.3A.7 sets out the contents of the test report.

Tests conducted by a certification body and a report prepared by it or by an accredited audit body may be accepted by the BNQ per the conditions set forth in section 4.2.

A.3A.1 TEST PLAN

Applicants are required to prepare a test plan for monitoring its treatment technology that takes account of the guidelines shown herein, completing it on the basis of the specific features of its treatment technology and the applications for which authorization is sought. An applicant or its representative may apply to the BNQ for approval of its test plan. Either one may be in charge of operating the treatment technology.

The technical information in the fact sheet will stem from the test results. As a consequence, the applicant and the engineer that signed the engineering report are responsible for ensuring that all conditions required for obtaining the desired fact sheet are met during the tests, including:

- Treatment system, such as its height
- Treated water, for example, flow, concentration and temperature values
- Operational factors such as dissolved oxygen and mixing level.

In addition, the applicant and its engineer (as signatory of the engineering report) are responsible for ensuring that the operational monitoring and sampling program will make it possible to obtain all data and information needed for a *Validated* fact sheet. A sheet may list more than one type of environmental monitoring for a single treatment system, leading to different design and performance criteria (such as different unit heights) for identical or modified systems. Applicants must contact the BNQ if it is desired that a fact sheet is to include more than three performance levels.

A.3A.2 TEST SUPERVISION

Test monitoring must be performed by a third party (see definition above).

Test supervision must make it possible to objectively check the accuracy of the performed and reported tests. Moreover, all required investigations must be performed in order to determine operational conditions both prior to and during sampling. These conditions must be logged and addressed in the test report.

Supervision must include measurement readouts that include temperature, dissolved oxygen, pH, liquid levels, flow, etc., as well as a sampling log, an event registry with a journal showing all operational parameters, sampling activity and a record of prevailing conditions during sampling.

The test report must include all compiled results, records and comments, analysis and interpretation of results related to the operating conditions and interventions, as well as hydraulic and mass balance of the treatment system. The test report must be written and signed by the third party qualified supervising professional.

A.3A.3 OPERATIONAL MONITORING

During inspections, the following must be noted: system status, indications and recordings from measurement equipment and all other instrumentation (including flowmeters and probes that measure temperature, dissolved oxygen, pH, liquid level and alarms). Device calibration must be checked and, when needed, tested for functionality. Robotic programming and calibration dates must be noted in the event registry.

The operational and stoppage times of equipment must also be noted. These include injection, transfer and recirculation pumps and, if applicable, operational speed, variator induction percentages and even the number of working cycles of stop-and-go equipment. As applicable, the following must also be noted: the volume of air injected into the reactors and the type, model, number and layout (dimensions, spacing, depth) of working aerators, as well as their operational mode (constant, intermittent (stop-and-go), variable with or without interruption), specific rates such as cubic metres of air per hour (m^3air/h) per cubic tank metre; m^3air/h per square metre at the surface of the tank, etc.

Event registry

The signatory of the test report is required to keep a registry of events and prevailing conditions during sampling, as well as a chronology of events and action taken on the treatment system, noting and reporting at least the following:

- The nature and quantity of products added (chemicals, nutrients, bacteria, enzymes, etc.) and the frequency of injection during the entire period of tests performed on the treatment system
- All noteworthy events, such as tuning, replacing a pump by another identical one, filtration material changes, and maintenance, including declogging and modification. Point A.3A.6 details the consequences that may be related to replacement and modification
- Water, sludge and other levels
- System, automate and instrumentation status
- Equipment calibration dates

- Treatment system sludge dating, if applicable
- Dates pertaining to residue extraction, quantity of residue extracted and mode of extraction used.

A.3A.4 SAMPLING PROGRAM

The sampling program, including the sampling dates or sequence starting on the first day of sampling must make it possible to determine the performance achieved by the technology under the test conditions.

Sampling must be carried out when the treatment system is operating under stable conditions. A stable condition may be associated with performance or a state with no significant change over time and could include the 5-day concentration of carbonated biochemical oxygen demand ($CBOD_5$) effluent or biofilm development.

In the event that the details of the sampling program in this appendix do not match the target application, the applicant or its representative may file with the BNQ for approval of its sampling program in the framework of an application to approve the test plan.

A.3A.4.1 Sampling process

Samples must be taken by a qualified individual per Cahier 1 – Généralités and Cahier 2 – Échantillonnage des rejets liquides of the *Guide d'échantillonnage à des fins d'analyses environnementales* issued by the Centre d'expertise en analyse environnementale du Québec (CEAEQ).

In the test report, the individual in charge of the test supervision must certify that the samples were taken by one or more qualified individuals and that sampling norms were met.

A.3A.4.2 Preservation of samples and analytical laboratories

Preservation and shipping
Sample preservation, shipping and storage must comply with paragraph 5.4 of ISO 5667-10:2020 and CEAEQ DR-09-04 (*Modes de conservation pour l'échantillonnage des rejets liquides-eaux usées* and all directives issued by the accredited laboratory. In the test report, the individual in charge of supervising the treatment system tests must certify that sample preservation and shipping complied with appropriate conditions and timelines prior to laboratory delivery.

Sample analysis laboratories
Sample analysis must be performed by a CEAEQ-accredited or ISO/CEI 17025-compliant independent laboratory. The accreditation body must be signatory to the ILAC (International Laboratory Accreditation Cooperation) Mutual Recognition Arrangement or MRA.

A.3A.4.3 Treatment stage parameters and sampling frequency

Test duration shall be at least 52 consecutive weeks covering a minimum of 365 days or 52 deemed consecutive weeks. This timeline allows for one or more disruptions related to a power outage or peripheral equipment breakdown (pumps, blowers, etc.). Nonetheless, each official monitoring segment must comprise periods of at least five consecutive weeks for a total of at least 52 official weeks, as shown in the following example: 40 consecutive weeks + outage + 2 consecutive weeks + breakdown + 12 consecutive weeks. Flow and load values must be similar before and after the disruption. Subsequent to a disruption, a load build-up period may be required before restarting official monitoring.

Sampling and analysis programs must minimally comprise the following, including 30 days of affluent and effluent sampling:

- January-April inclusively when only 15 days of sampling are conducted: no samples or one sample per week
- July-September inclusively when only 10 days of sampling are conducted: no sampling or one sample per week
- May, June and October-December: monthly samples.

A treatment system may perform a one-time stage, such as $CBOD_5$ reduction, or a combination of treatment stages such as the reduction of dissolved $CBOD_5$, total suspended solid (TSS), BOD_5, fecal coliforms, etc. A sampling program for a typical domestic wastewater treatment system must take account of the information relating to the treatment stages that is shown in Table A.3.1.

For treatment systems composed of a series of processing equipment units such as biological reactors, intermediate monitoring (not described in detail herein) would allow the applicant to show the performance of different portions of the treatment technology. As previously mentioned, the applicant or its representative may submit a request to the BNQ for approval of its sampling program in the framework of an application to approve its test plan, prior to testing.

Table A.3.1: At least 52 weeks–parameters and number of analyses

NORMAL TREATMENT STAGE MIMIMUM PARAMETERS	MINIMUM NUMBER OF SAMPLING DAYS	
	BEFORE TREATMENT(1)	AFTER TREATMENT(1)
Dissolved $CBOD_5$ reduction		
$CBOD_5$	**30**	**30**
Dissolved $CBOD_5$	**30**	**30**
TSS	**30**	**30**
Temperature	**30**	**30**(2)
Dissolved oxygen(3)		**30**
$CBOD_5$ and TSS reduction		
$CBOD_5$	**30**	**30**
Dissolved $CBOD_5$	**30**	
TSS	**30**	**30**(2)
Temperature		**30**
pH		**30**
Dissolved oxygen(3)		**30**
Reduction of solids		
TSS	**30**	**30**
VSS	**30**	**30**
Temperature	**30**	**30**
pH		**30**
Total phosphorous reduction (TP) (chemical coagulation)		
TP	**30**	**30**
pH		**30**
Alkalinity	**30**	
Fecal coliform reduction (FC) (disinfection)		
FC(4)	**30**	**30**
Ammonia reduction (NH_3-NH_4) (nitrification)		
Total Kjeldahl nitrogen (TKN)	**30**	
Ammoniacal nitrogen (NH_4^+)	**30**	**30**
Nitrites and nitrates (NO_2-NO_3)		**30**
pH		**30**
Alkalinity	**30**	

(1) The notions of before and after treatment refer to the treatment system that is subject to certification. Before and after treatment sampling is performed on the same day.

(2) To be added if effluent becomes the affluent of another part of the system whose individual performance values will be requested on the sheet.

(3) In or at the outlet of each reactor.

(4) Given the wide variability of fecal coliform results, a greater number of results will be needed. Three one-time samples must be withdrawn at distinct times on each sampling day and separately analyzed [3 values per day x 30 days = 90 sample values)]. Samples withdrawn on the same day must be spaced out by at least two hours.

Complementary monitoring may be required to better document the quality of water to be treated or that was treated, as well as the by-products formed during the treatment process. As an indication, the analysis of iron and manganese, transmittance and treated water hardness may be relevant to any expected additional UV disinfection. A non-exhaustive list of analytical parameters that have not been previously enumerated includes COD (chemical oxygen demand), orthophosphates (o-PO_4), volatile suspended solids (VSS), calcium, volatile organic compounds (VOC), conductivity, aluminum, oils and greases,

Langelier index, redox potential, total dissolved solids (TDS), and sulphur and hydrogen sulphide (H_2S).

A.3A.5 FLOW, CONCENTRATION AND LOAD

Flow

Average daily and maximum hourly flow values are shown on the fact sheet. The volume of water processed by the treatment system must be continuously measured by means of a flow totalizer or pump time recorder. If a pump time recorder is used, pump flow-through must be calibrated. Cumulative daily volume readouts must be taken. For hourly peak flow validation, which is not the same as average daily flow, continuous flow monitoring must be hourly, or every six hours if the flow is variable at that interval.

Average daily flow

For the purpose of validation, average daily flow shown on the fact sheet is the average of daily flow values measured during the entire test period.

Maximum hourly flow

When flow at the affluent of the treatment system is in continuous flow in receiving the totality of a sewer system (except for overflow), with or without pumping, the maximum hourly flow recorded in the fact sheet will be the average of maximum volumes recorded during 60 consecutive minutes on each day of the test period.

When the affluent flow of the system is controlled using pre-set values, a flow range of between 50% and 200% of average flow is deemed representative of flow variations that are inherent to the functioning of a treatment facility. The flow variation must be induced on a daily basis in the following proportion:

- 25% of the time (six hours a day) at 50% or less of average flow
- 25% of the time (six hours a day) at 200% or more of average flow.

Variation can be controlled on the basis of sine or square waves. In such cases, the maximum daily flow recorded in the fact sheet will be the average of maximum volumes during 60 consecutive minutes on each day of the test period. When no hourly data is available, the peak hourly flow recorded in the fact sheet will be the hourly average of the maximum volumes processed during six-hour periods (25% of the time) on each day of testing.

If the treatment system is not fed by the totality of the sewer system and the instructions regarding flow variation 25% of the time at 50% or less of average flow and 25% of the time at 200% of average flow are not followed, the maximum hourly flow will be deemed identical to the average daily flow on an hourly basis.

For peak hourly dosage equipment flow, refer to the applicable protocol in Appendix 3B.

Average concentration

The average concentration recorded in the sheet is for the full testing period. It is calculated from the overall average of daily concentrations measured without considering flow.

Average load

The average load recorded in the sheet is for the full testing period. It is calculated from the daily load measured on each of the sampling days. Daily load is calculated by multiplying daily flow by daily concentration for each sampling day.

A.3A.6 REPLACEMENT AND MODIFICATION DURING TESTING

Replacing a unit such as a pump or valve by an identical or equivalent one is not considered to be a modification. Nonetheless, this kind of replacement made because of equipment fatigue or wear and tear must be recorded in the test report and on the fact sheet.

No modification should normally be made to the facility when testing a treatment system. However, if a change becomes required, treatment system test monitoring must comply with point A.3A.4.

Notwithstanding the preceding, applications for a monitoring change or previously approved test plan per point A.3A.4 can be submitted to the BNQ (see section 4.3).

A.3A.7 CONTENTS OF THE TEST REPORT

The treatment system test report, which must list the prevailing operational conditions before and after sampling was performed, can be incorporated into the engineering report. Moreover, the report should comment on the effect on results of any intervention that occurred or operational conditions and events that were observed during testing. The test report must be signed by the individual that supervised the tests.

The test report must include the following:

- Operational conditions prevailing before and after sampling, including equipment and instrumentation control modes such as operational instructions
- Nature of added products such as coagulants, coagulant aids, oxidants or other additives, as well as their quantities and frequency of addition during the monitoring period
- Flow measurement procedures and the location of measurement and withdrawal points
- Method used for sampling and the mode used for sample preservation and shipping
- Certification that samples were taken by a knowledgeable qualified individual using sampling and preservation methodology standards such as are found in Booklets 1 and 2 of the *Guide d'échantillonnage à des fins d'analyses environnementales*)
- A description of all noteworthy events that occurred (equipment breakdown, repairs, replacement, tuning, changes made to the treatment system, etc.)
- Interpretation of the effect on results of interventions, operational parameters and events observed during testing
- Presentation of all compiled analytical results (append the laboratory test certificates). All results, as well as ADL-3, ADL-6 and ADL-12 (see Appendix 4), should be submitted as follows:

    - In tabular form, stating sampling dates and times (in the case of one-time sampling)
    - In graphic form, based on sampling dates or corresponding number of days
- Hydraulic and mass balance on the treatment system
- Reports and comments.

APPENDIX 3B

PERFORMANCE MONITORING FOR A VALIDATED FACT SHEET

DOSAGE EQUIPEMENT

APPENDIX 3B

PERFORMANCE TESTING FOR A VALIDATED FACT SHEET

DOSAGE EQUIPMENT

PREAMBLE

Appendix 3B describes the tests that must be performed on dosage equipment in cases where on-site calibration by the equipment operator is difficult to achieve over a short lapse of time. In such cases, equipment-delivered doses must be predetermined by a laboratory.

If Appendix 3B does not list a test plan for certifying a particular type of dosage equipment, the manufacturer (applicant) will be required to develop one and submit it to the BNQ for review. As applicable, the amended test plan will be added to Appendix 3B. Verification of the dosage equipment can then be conducted per the adopted test plan. The BNQ reviews requests for protocol development on a case-by-case basis, and test plans will be added following receipt and approval.

Dosage equipment that is part of the certification process for a treatment technology that includes several processing pieces of equipment will not require a separate validation sheet, per Appendix 3B, since it is deemed an integral part of previously authorized treatment technology and is inseparable in regard to achieving the discharge limits that are specified in the fact sheet.

LIST OF DOSAGE EQUIPMENT TEST PLANS

- 3B-I: Ultraviolet disinfection equipment validation monitoring

APPENDIX 3B-I

PERFORMANCE MONITORING FOR A VALIDATED FACT SHEET

ULTRAVIOLET DISINFECTION

PREAMBLE

The purpose of this type of validation monitoring is to confirm the effective doses provided by a UV reactor under various test conditions. Validation of the doses delivered by the unit is based on biodosimetric testing, with performance expressed as a delivered dose (microjoules per square centimetre [mJ/cm^2]).

Performance tests can be recognized even without biodosimetric testing, while being limited to the characterized treatment train and no possibility of transfer to other treatment trains. In such cases, the reader is encouraged to read Appendix 2 or 3A for information about treatment train validation procedures.

The design rules for large multiple-lamp systems have been documented in the literature and are addressed in the *Guide pour l'étude des technologies conventionnelles de traitement des eaux usées d'origine domestique*. The UV dose delivered by these systems can be estimated using average intensity (I_{avg}) equations and charts that have been published in a variety of reference works and relate to reactor configuration. Average intensity stated in these references is determined by calculation methods such as the point-source summation method (PSS).

However, no publication currently lists quantitative data on average intensity delivered by predesigned small reactors. As a general rule, manufacturers of this type of reactor use biodosimetric trials to determine the dose delivered by their reactor.

As of now, a single protocol has been approved by international certification bodies for low transmittance wastewater applications: the ETV/NSF – *Verification Protocol for Secondary Effluent and Water Reuse Disinfection Application*. However, the purpose of that protocol is to determine the dosages that are actually delivered by large, multiple-lamp UV reactors in order to qualify them for U.S. programs for Water reuse (EPA/600/R-12/618/September 2012 – *Guidelines for Water Reuse*).

The NSF/ANSI-55 – *Ultraviolet Microbiological Water Treatment Systems* protocol was developed to calibrate doses delivered by predesigned small reactors, but in drinking water applications which have very different conditions. As such, dosage calibration using the NSF/ANSI-55 protocol cannot be directly applied to wastewater UV disinfectant reactors.

A new protocol has therefore been proposed for validating the dose delivered by single-lamp small UV reactors originally designed for drinking water processing but also used today in wastewater applications. The proposed protocol is mainly based on the 2003

USEPA *Ultraviolet Disinfection Guidance Manual* (EPA 815-D-03-007) and on the 2004 *Ultraviolet Microbiological Water Treatment Systems* (NSF/ANSI-55).

This appendix details what is required for a *Validated* technical fact sheet.

- Points A.3B-I.2 to A.3B-I.8 describe the protocol and the disinfection equipment monitoring tests.
- Point A.3B-I.9 sets out the contents of the test report.

A.3B-I.1 TEST PLAN

Validation of the dose delivered by the unit for a *Validated* fact sheet is based on biodosimetric testing.

Biodosimetric testing includes a verification plan, calibration of phage response to the dose and calibration of the dose delivered at a given flow.

A.3B-I.2 TEST SUPERVISION

The test report must be prepared and signed by the third party supervisor.

Test supervision must make it possible to objectively verify the stringency of tests made and reported. Moreover, all required investigations must be conducted to determine the prevailing operational conditions before and after sampling, then logged and addressed in the test report.

Supervision must include measurement records for temperatures, dissolved oxygen, pH, liquid levels, flow, etc. All samples must be recorded, and an event registry that includes a journal listing all operational parameters, sampling activities and a record of conditions prevailing during sampling must be kept.

The test report must also include all compiled results, records and comments, as well as the analysis and interpretation of results based on operational conditions, required intervention and hydraulic and mass balance for the disinfection equipment. The test report must be prepared and signed by the third party supervising professional.

A.3B-I.3 OPERATIONAL MONITORING

Biodosimetric testing must be performed by an independent arm's length laboratory that is specialized in this field.

Event registry

The signatory of the disinfection equipment test report is required to include a registry of prevailing conditions during sampling, as well as a chronology of events and interventions on the disinfection equipment that notes and reports the following:

- The type and quantities of chemical, phage, bacteria, enzyme and other products, as well as their frequency of addition during the entire disinfection equipment validation period

- All noteworthy events, such as tuning, replacement of a pump by another, identical one, maintenance – such as cleaning a lamp and all disinfection equipment modifications. Point A.3B-I.6 sets out the consequences related to replacement and modification
- System, automate and instrumentation status
- Dates of equipment calibration

A.3B-I.4 SAMPLING PROGRAM

A.3B-I.4.1 Sampling process

Samples must be taken by a qualified individual under the supervision of the specialized laboratory in compliance with the specifications of the *Guide d'échantillonnage à des fins d'analyses environnementales,* *Cahier 1 – Généralités* *et* *Cahier 2 – Échantillonnage des rejets liquides*.

In the test report, the individual in charge of the test supervision must certify that the samples were taken by one or more qualified individuals and that the sampling norms were met.

A.3B-I.4.2 Sample preservation and analytical laboratories

Preservation and shipping
Sample preservation, shipping and storage must comply with paragraph 5.4 of ISO 5667-10:2020 and CEAEQ DR-09-04 – *Modes de conservation pour l'échantillonnage des rejets liquides (eaux usées)* and all directives issued by the accredited laboratory. In the test report, the individual in charge of supervising the treatment technology must certify that the samples were kept in appropriate conditions and were delivered to the laboratory within regulatory timelines.

Sample test laboratories
Sample analysis must be performed by a CEAEQ-accredited or ISO/CEI 17025-compliant independent laboratory. The accreditation body must be signatory to the ILAC (International Laboratory Accreditation Cooperation) Mutual Recognition Arrangement or MRA.

A.3B-I.4.3 UV DOSE VALIDATION

The dose must be defined by MS-2 ATCC 15597 coliphage biodosimetric tests.

The NSF/ANSI-55-2004 protocol must be used to determine the reduction equivalent "RED" dose, taking the following amendments into account:

- Chapters 4.0, 5.0 and 8.0 are not applicable.
- Paragraphs 6.2.1, 7.2.2.1, 7.2.2.2 and 7.2.2.8 are not applicable.
- Paragraph 7.2.1.3, sub-paragraph g) is amended as follows:
    - g) Determine the dose as percentages of the required dose, as follows: 0%, 15%, 30%, 45%, 60%, 75%, 90%, and 105%. Exposure times for each of the doses is determined by the following equation:

Exposure time = dose/E_{ave}

- Paragraph 7.2.1.3, sub-paragraph h) is amended as follows:
  - h) Prepare 16, 60 x 20 mm Petri dishes that include a 10 x 3 mm sterile stirring bar. Pour a sufficient amount of the suspension into each of the dishes, to a depth of 1 cm. Irradiate two dishes for each dose determined in sub-paragraph 7.2.1.3 g).

- Paragraph 7.2.2.5.1 is amended as follows:

7.2.2.5.1 Test target transmittances

Testing must be minimally carried out for transmittance that is representative of the wastewater at a given flow. However, testing may also be carried out for several predetermined levels of transmittance and flow.

If a single transmittance level is selected, it must be 45% or less. If more than one transmittance value is tested, it must also be 45% (or less), while it is recommended to test also at 55% and 65% levels.

The sampling procedure set out in paragraph 7.2.2.7 must be used for both reactors at a 45% transmittance or less.

The procedure set out in paragraph 7.2.2.7 may be used for a single transmittance at more than one flow in a single reactor if the RED discrepancy of each of the reactors at 45% transmittance is less than 5%. If this is not the case, the entire procedure described in paragraph 7.2.2.7 must be followed for both reactors.

- Paragraph 7.2.2.5.2, sub-paragraphs g), h) and i) are amended as follows:

7.2.2.5.2 Measurement of the rated power of the system

- g) Lamp intensity variation must be evaluated under application conditions that are representative of water in Québec. The lamp intensity variation curve must cover the temperature range of 25°C to 5°C at intervals of 5°C. Lamp intensity must be continuously measured and recorded during testing. The intensity of a lamp is measured and recorded after it has reached a stable state (±1 mW/cm^2) for more than 30 minutes.

- h) The operational temperature of the reactor lamp must be measured under conditions that are representative of water in Québec (range of 25°C to 5°C at intervals of 5°C). During testing, the temperature must be measured and recorded on a continuous basis. The temperature of a lamp must be measured and recorded after it has reached a stable state (±0.2 °C) for more than 30 minutes.

- i) The tests described in points g) and h) may be carried out simultaneously with an equivalent method.

- Paragraph 7.2.2.7, Table 6 is amended as follows:
  - **Table 6–Sampling procedure used for disinfection performance testing**

Day	System status	Sampling point	
		Inlet	Outlet
0	Preparation	No sample	No sample
1	Start-up (lamp off)	No sample	2 samples
1	Start-up (lamp on)	3 samples	3 samples
1	2 h	3 samples	3 samples
1	4 h	3 samples	3 samples
1	5 h (lamp off)	No sample	2 samples
• After each stagnation period and prior to sampling, a quantity of water that is at least five times the volume of the UV reactor must be purged from pipes and other units to ensure that all water has been replenished. • All samples are taken after 30 minutes of system operation.			

  - Paragraph 7.2.2.7, sub-paragraph a) is amended as follows:
    - a) Install two systems as shown in figure 3 of the NSF/ANSI-55-2004 protocol and check the facility with water that will be used for the tests per the manufacturer's recommendations. For reactors equipped for pre-filtering or post-filtering, the filters must be removed prior to testing. Install a three-way valve immediately upstream from the disinfection unit to enable bypass. Determine flow at each of the sampling points at several operational pressure levels. Determine the operational pressure level required for each of the target flow values. The UV lamp may be deactivated during these tests.
  - Paragraph 7.2.2.7, sub-paragraph d) is amended as follows:
    - d) Add PHBA as needed to reach the target transmittance. It is also possible to use a mixture of vanillin (CAS# 121-33-5) and SuperHume (humic acid) as presented in the NSF/ANSI-55-2019. The vanillin and SuperHume are combined in a ratio of 1.0 mg vanillin to 0.02 mL SuperHume.

A.3B-I.5 FLOW

The flow value(s) used during the tests and calibration method must be clearly stated in the test report. A cumulative volume readout must be taken for each test.

A.3B-I.6 REPLACEMENT AND MODIFICATION DURING TESTING

Replacing a unit such as a pump or valve by an identical or equivalent device is not considered to be a modification. Nonetheless, this kind of replacement made because of equipment fatigue or wear and tear must be recorded in the test report and the fact sheet.

No modification should be made to the facility when testing dosage equipment. However, if a modification is in fact made, test monitoring must be reinitialized.

A.3B-I.7 CONTENTS OF THE TEST REPORT

The disinfection equipment test report, which must list the prevailing operational conditions before and after sampling was performed, can be incorporated into the engineering report. The report should comment on the effect on results of any intervention that occurred, or operational conditions and events that were observed during testing. The test report must be signed by the test supervisor.

The test report must include the following:

- Operational conditions prevailing before and after sampling, including equipment and instrumentation control modes such as operational instructions
- Nature of added chemical, phage, bacteria, enzyme or other additives, as well as their quantities and frequency of addition during the monitoring period
- Flow measurement procedures and the location of measurement and withdrawal points
- Method used for sampling and the mode used for sample preservation and shipping
- Certification that samples were taken by a knowledgeable qualified individual using sampling and preservation methodology standards (ex. Booklets 1 and 2 of the *Guide d'échantillonnage à des fins d'analyses environnementales*)
- A description of all noteworthy events that occurred (equipment breakdown, repairs, replacement, tuning, changes made to the dosage equipment, etc.)
- Presentation of all compiled analytical results (append the laboratory test certificates). All results should be submitted as follows:
    - In tabular form, stating sampling dates and times. Tables must show averages and standard deviations
    - In graphic form, based on operational parameters such as transmittance and flow, showing regression confidence intervals if applicable
- Reports and comments.

A.3B-I.8 CONTENTS OF THE TECHNICAL FACT SHEET

In addition to what is set out in Appendix, the *Validated* fact sheet must state that the ascribed dose was validated by biodosimetric testing. The UV lamp and sleeve aging curve must also be shown, as well as the effect of the water temperature on submersed lamps or similar devices, based on the results of intensity testing.

Any sleeve grime accumulation due to design issues found during testing must be stated on the sheet for informational purposes.

If the dose validation was based on several loads (transmittance and/or flow) the data regression curve equation should be shown on the sheet.

APPENDIX 4

STATISTICAL METHOD USED TO DEFINE DISCHARGE LIMITS

APPENDIX 4

STATISTICAL METHOD USED TO DEFINE DISCHARGE LIMITS

In the procedure under review, the capacity of a treatment system to meet a given discharge requirement is assessed on the basis of monitoring results with the statistical method shown herein. In order for the expected performance of a treatment system to meet the discharge requirement as defined for the facility, the probability of concentration not exceeding the probable maximum is set at 99% with a 95% certainty. This concentration level is defined by a discharge limit for average three, six and twelve ADL results (ADL-3, ADL-6 and ADL-12). Average discharge limits are determined by the statistical analysis of monitoring data.

The United States Environmental Protection Agency (USEPA, 1991) has proposed a statistical method to define discharge norms for wastewater treatment systems. The proposed statistical method makes it possible to determine the maximum probable daily and monthly discharge concentration values that may be achieved by a treatment system based on monitoring results of treated effluent water and by taking account of observed (or estimated) effluent variation.

This appendix describes how to apply the statistical method to a data series obtained from processed effluent.

A.4.1 THE STATISTICAL METHOD PROPOSED BY THE USEPA

It is a recognized fact that many physical phenomena can be interpreted using characteristics that flow from the laws of statistics. It has also been observed that for any given contaminant, concentrations in processed effluent vary from one day to the next in spite of correct treatment system design and adequate operation.

The variability of discharge quality can be attributed to many factors, notably processing variations, fluctuation in flow rate or pollutant load, short-term adjustments to treatment equipment, wastewater temperature and, sometimes, ambient temperature, reliability of samples and measurements, etc. It is thus quite normal for the concentration levels of contaminants in treated water to be higher on certain days.

To take account of the intrinsic variability of effluent, the USEPA (1991) suggests applying two standards, one daily and the other, monthly, that emerge from the statistical analysis of monitoring data. In setting a daily standard – which is in fact a maximum discharge limit –, the EPA acknowledges that effluent concentrations at a given plant can on occasion exceed it. By also establishing a monthly norm, the USEPA constrains the use of high daily values and to that end, recommends that average daily and monthly standards applicable to a given facility correspondent respectively to the 99th centile and the 95th centile of the distribution of concentration data for treated effluent.

Moreover, whenever available data is limited in number, the USEPA recommends an approach based on a combination of the assessment of effluent variability defined by the standard deviation in the series of measurements, and the uncertainty caused by the limited number of measurements.

The method suggested by the USEPA rests on the assumption that if a series of representative monitoring data of the performance of a treatment system shows that data is time-independent (any particular value does not depend on the preceding value), the distribution of processed effluent monitoring data will be normal, lognormal or delta-lognormal.

These assumptions imply that operational conditions do not change during the period of characterization of the performance of the treatment system, and that the latter is stable over time.

Consequently, conclusions drawn from statistical evaluation are valid for conditions observed during the period of performance characterization of any given treatment system.

A.4.1.1 Limits of measurement methods

An experimental method cannot detect the presence of a contaminant with certainty when it is present below a specific concentration. Also, an experimental method cannot determine with certainty the concentration of a contaminant when it is present below a specific concentration. These are, respectively, the limits of detection and quantification.

When many values of a sample of a population are below the detection limit, the USEPA (1991; 2004) recommends using the delta-lognormal method to perform statistical calculations.

A.4.2 STATISTICAL CALCULATIONS

For a population of observations that follows normal distribution, the average (μ) can be obtained from the following equation:

$$\mu = \sum_{i}^{n} y_i / n$$

y_i = each effluent concentration datum
n = number of data values

and the standard deviation (σ) can be obtained from the following equation:

$$\sigma = \sqrt{\frac{\sum_{i}^{n} (y_i - \mu)^2}{n-1}}$$

For a population of observations that follows normal distribution, the probability that a given value is less than a critical value can be defined as:

$$P(Z \leq z) = \frac{1}{\sqrt{2\pi}} \int^{z} e^{-z^2/2}$$

A.4.2.1 Tolerance limit

Since the characteristics of an effluent have intrinsic variability, the objective of the validation process is not to define the average performance of the treatment system, but rather to define its capacity to meet annual or periodic requirements. Therefore, a single observation or group of observations should meet a given requirement over a given period of time. The objective is thus to define the tolerance limits that encompass the entire body of observations to an acceptable centile $(1 - \alpha)$.

When a group of representative observations of the population (n = a finite value) is available, the standard deviation of the group "*s*" may differ from the standard deviation of the population (σ). It is thus useful to determine the certainty $(1 - \gamma)$ of "*s*" in assessing the limits. The tolerance limit can then be determined to a level of certainty and an acceptable centile using the following equation:

$$LT = \mu + k_{\alpha,\gamma} s$$

The tolerance factor $k_{\alpha,\gamma}$ is provided in statistical tables that were calculated for this purpose (Walpole et al, 1998; NIST/SEMATECH, 2007).

Tolerance limit for an average

For a sample of observations where the standard deviation "s" has been determined, it is possible to determine the standard deviation $s_{\bar{y}}$ of a given sub-group of observations.

$$s_{\bar{y}} = \frac{s}{\sqrt{m}}$$

It is thus possible of to determine the tolerance limit for the average of a defined number of values (m) with the following equation:

$$LT = \mu + k_{\alpha,\gamma} s_{\bar{y}}$$

A.4.2.2 Data validation

In order to calculate the discharge limits for a given contaminant, it is necessary to compile the concentration effluent data and follow these steps:

1. Prepare a daily data distribution graph and verify the type of distribution.
2. Validate data in accordance with the type of distribution; then eliminate aberrant values.

   However, prudence must be observed when eliminating data, since a very high or very low result may in fact reflect a normal situation. When limited data is available, the elimination of a very high or very low value can significantly influence the average and other calculations that follow from it.

Prior to calculating value limits, data must be processed according to the assumptions that are inherent to statistical methods. Calculation of an average value or standard deviation can be made from a group of values that follows normal distribution. However, if the distribution of the group of

values does not reflect this hypothesis, transformation is required to ensure normal distribution of values.

Logarithmic transformation of measurements is used to normalize the distribution of effluent observations when their distribution is lognormal.

Weighting of the average and standard deviation in proportion to the fraction of values under the detection threshold must start from the arithmetic value of the average and the standard deviation. This can require several additional transformations, depending on the form of the distribution.

A.4.3 DISCHARGE LIMITS

In Québec, domestic wastewater treatment station discharge requirements are expressed as periodic, seasonal or annual averages. With the requirements of the MELCC, the treatment station effluent average is obtained over three, six or twelve daily results, respectively. To ensure consistency between the standard and the calculated discharge, discharge limit evaluation must be conducted in a way that reflects how the standard was formulated. This explains why the averages are calculated for results at three, six and twelve results (ADL-3, ADL-6 and ADL-12).

In order for the standard performance of a technology to meet the discharge requirements that are defined for the facility, the probability of not exceeding the tolerance limit is set at 99% with a 95% certainty. Defined as such, the tolerance limit will be higher than the limit observed during testing. Therefore, in order to comply with the probability of the tolerance limit not being exceeded, the discharge limit standard needs to be higher than the tolerance limit.

Average discharge limit of three results (ADL-3)

For the purposes of new technology performance validation, the tolerance limit of three results average is determined using the proposed method to define discharge limits in accordance with a centile not exceeding 99%, with a confidence level of 95% for an average of 3 measurements.

Average discharge limit of six results (ADL-6)

For the purposes of new technology performance validation, the tolerance limit of six results average is determined using the proposed method to define discharge limits in accordance with a centile not exceeding 99%, with a confidence level of 95% for an average of 6 measurements.

Average discharge limit of twelve results (ADL-12)

For the purposes of new technology performance validation, the tolerance limit of twelve results average is determined using the proposed method in order to define discharge limits in accordance with a centile not exceeding 99%, with a confidence level of 95% for an average of 12 measurements.

A.4.3.1 CALCULATION OF REQUIRED AVERAGE ARITHMETIC DISCHARGE LIMITS

The discharge limit calculation method must take into account the form of the statistical distribution of data and the calculation method used for discharge requirements. For $CBOD_5$, TSS, nitrogen and phosphorus, discharge requirements correspond to the average calculated arithmetic value.

A.4.3.1.1 Calculation method for normal distribution

When the distribution of monitoring data is normal, calculations of tolerance limits can be made as follows:

Calculation of the average

$$\mu = \sum_{i}^{n} y_i / n$$

y_i = each effluent concentration datum
n = number of data values

Calculation of the standard deviation

$$s = \sqrt{\frac{\sum_{i}^{n} (y_i - \mu)^2}{n-1}}$$

Calculations of ADL-3, ADL-6 and ADL-12

$$ADL\text{-}3 = \mu + k_{\alpha,\gamma} * \frac{s}{\sqrt{3}}$$

$$ADL\text{-}6 = \mu + k_{\alpha,\gamma} * \frac{s}{\sqrt{6}}$$

$$ADL\text{-}12 = \mu + k_{\alpha,\gamma} * \frac{s}{\sqrt{12}}$$

ADL-3	=	Average discharge limit of 3 results
ADL-6	=	Average discharge limit of 6 results
ADL-12	=	Average discharge limit of 12 results
μ	=	Average of the series of measurements
$k_{\alpha,\gamma}$	=	Tolerance factor for a number of data, with a confidence level α and a centile γ defined in the statistical tables.
s	=	Standard deviation of the series of measurements
n	=	Number of values in the series of measurements
m	=	Number of measurements of 3, 6 or 12 results average.

A.4.3.1.2 Calculation method for lognormal distribution

Generally speaking, sewage treatment plant effluent monitoring data have lognormal distribution.

When the distribution is lognormal, it is necessary to transform arithmetic values into logarithmic values before performing calculations. This transformation brings distribution into normal form in order that the usual statistical methods can be applied.

Subsequent to statistical calculations, it is necessary to reconvert the results into arithmetic values to obtain ADL-3, ADL-6, and ADL-12.

Transformation into logarithmic values is made using the following equation:

$$\mathbf{w_i = \ln (y_i)}$$

y_i = each effluent concentration datum
w*i* = logarithmic value of each effluent concentration datum

Calculation of the average

$$\mu_w = \sum_i^n w_i / n$$

μ_w = average of the logarithmic value of effluent concentration data
w_i = logarithmic value of each effluent concentration datum
n = number of data values

Calculation of the standard deviation

$$s_w = \sqrt{\frac{\sum_i (w_i - \mu_w)^2}{n-1}}$$

Calculations of ADL-3, ADL-6 and ADL-12

E (y) $= \exp\left[\mu_w + \frac{(s_w)^2}{2}\right]$

Var (y) $= \exp\left[2\mu_w + (s_w)^2\right]\left[\exp\left[(s_w)^2\right] - 1\right]$

Var (y) $_m$ [1] $= \frac{Var(y)}{m}$

$E(y)_m$ = E(y)

$\sigma_m = \sqrt{\ln\left(\frac{Var(y)_m}{[E(y)]^2} + 1\right)}$

$\mu_m = \ln(E(y)) - 0{,}5(\sigma_m)^2$

ADL-3 [2] $= \exp\left(\mu_m + k_{\alpha,\gamma}\sigma_m\right)$

ADL-6 [2] $= \exp\left(\mu_m + k_{\alpha,\gamma}\sigma_m\right)$

ADL-12 [3] $= E(y)_m + k_{\alpha,\gamma}\sqrt{Var(y)_m}$

[1] Since requirements are based on an arithmetic average, the standard deviation of a group of arithmetic averages must be determined on the arithmetic value.
[2] When the distribution of a group of data follows lognormal distribution, the USEPA assumes that the distribution of a series of averages of less than 10 values follows lognormal distribution.
[3] The USEPA assumes that the distribution of a series of averages of 12 values follows normal distribution.

ADL-3	=	Average discharge limit of 3 results
ADL-6	=	Average discharge limit of 6 results
ADL-12	=	Average discharge limit of 12 results
μ_w	=	Average of the logarithmic value of measurements
s_w	=	Standard deviation of the logarithmic value of measurements
Var(y)	=	Standard deviation of a series of measurements
$\mathrm{Var}(y)_m$	=	Standard deviation of a series of averages
E (y)	=	Average of a series of measurements
$k_{\alpha,\gamma}$	=	Tolerance factor of for a number of data, with a confidence level α and a centile γ defined in the statistical tables
μ_m	=	Logarithmic value of the calculated average
σ_m	=	Logarithmic value of the standard deviation calculated for a series of 3, 6 or 12 results average
n	=	Number of data values in the series of measurements
m	=	Number of measurements of 3, 6 or 12 results average

A.4.3.1.3 Calculation method for delta-lognormal distribution

When a delta (δ) proportion of values falls below the detection threshold of the method of measurement (D), the distribution becomes delta-lognormal.

If distribution is delta-lognormal, the weighting of the average and the standard deviation in proportion to the fraction of values under the detection threshold must be performed on the arithmetic values of the average and the standard deviation. This may require several additional transformations, depending on the form of the distribution. It is then necessary to transform the values above the threshold of detection (yc) into logarithmic values before performing the calculations. This transformation brings the distribution of the values located above threshold of detection into normal form so that the usual statistical methods can be applied to this series of values.

According to the USEPA, the value of the desired tolerance limit centile may be determined by formulating the hypothesis that the calculated average can be weighted in the following proportion:

$$\mu(U) = \delta D + (1 - \delta)\mu(yc)$$

The variance can be weighted in the following proportion:

$$Var(U) = \delta D_2 + (1 - \delta)(Var(yc) + [\mu(yc)]^2) - \mu(U)$$

Calculation of the delta (δ) proportion of the values that are below the detection threshold of the measurement method:

$$\delta = r/k$$

r = number of measurements below the detection threshold
k = total number of measurements
δ = number of measurements below the detection threshold

Transformation of measurement data above the detection threshold into logarithmic values is made with the following equation:

$$w_i = \ln(y_i)$$

y_i = each concentration datum in the effluent
w_i = logarithmic value of effluent concentrations above the detection threshold

Calculations for the average of n_m values

Calculation of the average of the logarithmic values of data above the detection threshold

$$\mu_w = \frac{\sum_{i}^{k-r} w_i}{(k-r)}$$

μ_w = average of the logarithmic value of effluent concentration data above the detection threshold
w_i = logarithmic value of effluent concentration data above the detection threshold
k − r = number of data values above the detection threshold

Calculation of the standard deviation of the data series (s_w) converted into logarithmic values:

$$s_w = \sqrt{\frac{\sum_{i}^{k\text{-}r} (w_i - \mu_w)^2}{(k\text{-}r) - 1}}$$

ADL-3, ADL-6 and ADL-12 calculations

E(y) $$= \exp\left[\mu_w + \frac{(s_w)^2}{2}\right]$$

Var(y) $$= (E(y))^2\left(\exp\left[(s)^2\right] - 1\right)$$

E(Y*) $$= \delta D + (1-\delta)E(y)$$

Var(Y*) $$= \delta D^2 + (1-\delta)\left[Var(y) + (E(y))^2\right] - E(Y^*)$$

A $$= \frac{Var(Y^*)}{\left[m\left(E(Y^*) - \delta^m D\right)^2\right]}$$

B $$= \frac{-\left[\delta^m D^2 (1-\delta^m)\right]}{\left[E(Y^*) - \delta^m D\right]^2}$$

C $$= \frac{\left[2\delta^m D\right]}{\left[E(Y^*) - \delta^m D\right]}$$

σ_m^2 $$= \ln\left\{\left(1-\delta^m\right)\left[1 + A + B + C\right]\right\}$$

μ_m $$= \ln\left[\frac{\left(E(Y^*) + \delta^m D\right)}{(1-\delta^m)}\right] - 0{,}5\sigma_m^{\,2}$$

γ $$= \frac{(0{,}99-\delta)}{(1-\delta)}$$

ADL-3 $$= \exp\left(\mu_m + k_{\alpha,\gamma}\,\sigma_m\right)$$

ADL-6 $= \exp\left(\mu_m + k_{\alpha,\gamma}\, \sigma_m \right)$

ADL-12 $= E(y)_m + k_{\alpha,\gamma} \sqrt{Var(y)_m}$

ADL-3	=	Average discharge limit of 3 results
ADL-6	=	Average discharge limit of 6 results
ADL-12	=	Average discharge limit of 12 results
μ_w	=	Average of the logarithmic values of measurements above the detection threshold
s_w	=	Standard deviation of the logarithmic values of measurements above the detection threshold
Var (y)	=	Standard deviation of measurements above the detection threshold
E (y)	=	Average of measurements above the detection threshold
Var(Y*)	=	Weighted standard deviation of measurements
E(Y*)	=	Weighted average of measurements
$K_{\alpha,\gamma}$	=	Data series tolerance factor with confidence level α and centile γ as defined in the statistical tables
μ_m	=	Logarithmic value of the weighted average for a series of 3, 6 or 12 results averages
σ_m	=	Logarithmic value of the weighted standard deviation for a series of 3, 6 or 12 results average
k −r	=	Number of values above the detection threshold of the measurement method
δ	=	r/k
n	=	Number of values in the series of measurements
m	=	Number of measurements of 3, 6 or 12 results average

A.4.3.2 CALCULATION OF REQUIRED AVERAGE GEOMETRIC DISCHARGE LIMITS

The discharge limit calculation method must take into account the form of the statistical distribution of data as well as the discharge requirement calculation method. For fecal coliforms, the discharge requirement corresponds to the calculated geometric average for the period.

Consequently, the standard deviation of a group of geometric averages must be determined by using the standard deviation of logarithmic values.

A.4.3.2.1 Lognormal distribution calculation method

Generally speaking, effluent treatment plant monitoring data follow lognormal distribution.

When distribution is lognormal, it is necessary to transform data into logarithmic values prior to performing calculations. This transformation brings distribution into normal form to enable the usual statistical methods to be applied. Once statistical calculations have been made, results must be reconverted into arithmetic values to obtain ADL-3, ADL-6 and ADL-12.

The following equation is used to transform data into logarithmic values:

$w_i = \ln (y_i)$

x_i = individual effluent concentration datum
y_i = logarithmic value of each effluent concentration datum

Calculation of the average

$$\mu_w = \sum_i^n w_i / n$$

μ_w = average logarithmic value of effluent concentration data
w_i = logarithmic value of each effluent concentration datum
n = number of data values

Calculation of the standard deviation

$$s_w = \sqrt{\frac{\sum_i (w_i - \mu_w)^2}{n-1}}$$

Calculations of ADL-3, ADL-6 and ADL-12

$$\sigma_m = \frac{s_w}{\sqrt{m}}$$

ADL-3 $= \exp\left[\mu_w + k_{\alpha,\gamma}\sigma_m\right]$

ADL-6 $= \exp\left[\mu_w + k_{\alpha,\gamma}\sigma_m\right]$

ADL-12 $= \exp\left[\mu_w + k_{\alpha,\gamma}\sigma_m\right]$

ADL-3	=	Average discharge limit of 3 results
ADL-6	=	Average discharge limit of 6 results
ADL-12	=	Average discharge limit of 12 results
μ_w	=	Average of the logarithmic values of measurements
s_w	=	Standard deviation of logarithmic values of measurements
σ_m	=	Calculated standard deviation for a series of 3, 6 or 12 geometric averages results
$\kappa_{\alpha,\gamma}$	=	Data series tolerance factor with confidence level α and centile γ as defined in the statistical tables
nr	=	Number of values in the series of measurements
m	=	Number of measurements of 3, 6 or 12 results average

A.4.3.2.2 Delta lognormal distribution calculation method

When a delta (δ) proportion of values falls below the detection threshold of the method of measurement (D), the distribution becomes delta-lognormal. The weighting of the average and the standard deviation in proportion to the fraction of values under the detection threshold must be performed on the arithmetic value of the average and the standard deviation. This may require several additional transformations, depending on the form of the distribution.

If the delta distribution is lognormal, the logarithmic values of measurements above the detection threshold (x_C) follow normal distribution.

According to the USEPA, the value of the desired tolerance limit centile can be determined by formulating the hypothesis that the calculated average can be weighted in the following proportion:

$$\mu(U) = \delta D + (1 - \delta)\mu(xc)$$

The variance can be weighted in the following proportion:

$$Var(U) = \delta D_2 + (1 - \delta) (Var (xc) + [\mu(xc)]^2) - \mu(U)$$

Calculation of the delta (δ) proportion of the values which are below the detection threshold of the measurement method:

$$\mathbf{\delta = r/k}$$

r = number of measurements below the detection threshold
k = total number of measurements
δ = number of measurements below the detection threshold

The transformation of the values above the detection threshold into value logarithmic equation is made with the following equation:

$$\mathbf{w_i = ln(y_i)}$$

y_i = each concentration datum in the effluent
w_i = logarithmic value of effluent concentrations above the detection threshold

Calculations for an average of n_m values

Calculation of the average of the logarithmic values of data above the detection threshold:

$$\mu_w = \frac{\sum_i^{k-r} w_i}{(k-r)}$$

μ_w = average of the logarithmic value of effluent concentration data above the detection threshold
w_i = logarithmic value of effluent concentration data above the detection threshold
k − r = number of data values above the detection threshold

Calculation of the data series standard deviation (s_w) converted into value logarithmic values:

$$s_w = \sqrt{\frac{\sum_i^{k-r} (w_i - \mu_w)^2}{(k-r)-1}}$$

ADL-3, ADL-6 and ADL-12 calculations

$$\mu_C = \delta \ln(D) + (1-\delta)\mu_w$$

$$\frac{(\sigma_c)^2}{m} = \frac{\left\{\delta[\ln(D)]^2 + (1-\delta)\left(\mu_w{}^2 + s_w{}^2\right) - \mu_c{}^2\right\}}{m}$$

$$(\sigma_c)_m = \sqrt{\frac{(\sigma_c)^2}{m}}$$

$$\text{ADL-3} = \exp\left(\mu_c + k_{\alpha,\gamma}(\sigma_c)_m\right)$$

$$\text{ADL-6} = \exp\left(\mu_c + k_{\alpha,\gamma}(\sigma_c)_m\right)$$

$$\text{ADL-12} = \exp\left(\mu_c + k_{\alpha,\gamma}(\sigma_c)_m\right)$$

ADL-3	=	Average discharge limit of 3 results
ADL-6	=	Average discharge limit of 6 results
ADL-12	=	Average discharge limit of 12 results
μ_w	=	Average of the logarithmic values of measurements above the detection threshold
s_w	=	Standard deviation of the logarithmic values of measurements above the detection threshold
$K_{\alpha,\gamma}$	=	Data series tolerance factor with confidence level α and centile γ as defined in the statistical tables
μ_c	=	Weighted average of the logarithmic values of measurements
$(\sigma_C)_m$	=	Weighted standard deviation of a logarithmic values of a series of 3, 6 or 12 results averages
k-r	=	Number of values above the detection threshold of the measurement method
δ	=	r/k
n	=	Number of values in the series of measurements
m	=	Number of measurements of 3, 6 or 12 results average

Table A.5-1 - $K_{\alpha,95}$ tolerance factor

95% Confidence Level								
Centile								
	$t_{f50/95}$	$t_{f55/95}$	$t_{f60/95}$	$t_{f70/95}$	$t_{f80/95}$	$t_{f90/95}$	$t_{f95/95}$	$t_{f99/95}$
k	**0.50**	**0.55**	**0.60**	**0.70**	**0.80**	**0.90**	**0.95**	**0.99**
2	0.000	2.454	4.943	10.237	16.450	25.007	32.138	45.462
3	0.000	0.639	1.287	2.666	4.284	6.513	8.370	11.840
4	0.000	0.410	0.826	1.710	2.748	4.178	5.369	7.595
5	0.000	0.326	0.657	1.361	2.188	3.326	4.274	6.046
6	0.000	0.283	0.571	1.183	1.900	2.889	3.713	5.252
7	0.000	0.257	0.518	1.073	1.734	2.621	3.369	4.766
8	0.000	0.239	0.482	0.999	1.605	2.440	3.136	4.436
9	0.000	0.227	0.456	0.945	1.519	2.308	2.967	4.197
10	0.000	0.217	0.437	0.904	1.453	2.209	2.838	4.015
11	0.000	0.209	0.421	0.872	1.401	2.130	2.737	3.872
12	0.000	0.203	0.408	0.846	1.359	2.066	2.655	3.756
13	0.000	0.198	0.398	0.824	1.324	2.013	2.587	3.659
14	0.000	0.193	0.389	0.806	1.295	1.968	2.529	3.578
15	0.000	0.189	0.381	0.790	1.269	1.930	2.480	3.508
16	0.000	0.186	0.375	0.776	1.247	1.896	2.437	3.448
17	0.000	0.183	0.369	0.764	1.228	1.867	2.400	3.394
18	0.000	0.181	0.364	0.754	1.211	1.841	2.366	3.347
19	0.000	0.178	0.359	0.744	1.196	1.818	2.337	3.306
20	0.000	0.176	0.355	0.736	1.182	1.797	2.310	3.268
25	0.000	0.169	0.340	0.703	1.130	1.718	2.208	3.124
30	0.000	0.163	0.329	0.682	1.095	1.665	2.140	3.027
33	0.000	0.161	0.324	0.672	1.079	1.640	2.108	2.982
35	0.000	0.160	0.321	0.666	1.070	1.26	2.090	2.957
40	0.000	0.157	0.316	0.654	1.050	1.597	2.052	2.902
45	0.000	0.154	0.311	0.644	1.035	1.576	2.021	2.859
50	0.000	0.152	0.307	0.636	1.022	1.554	1.997	2.824
55	0.000	0.151	0.304	0.629	1.011	1.537	1.976	2.795
60	0.000	0.149	0.301	0.624	1.002	1.524	1.958	2.770
65	0.000	0.148	0.299	0.619	0.994	1.512	1.943	2.748
70	0.000	0.147	0.297	0.614	0.987	1.501	1.929	2.729
75	0.000	0.146	0.295	0.611	0.981	1.492	1.917	2.712
80	0.000	0.146	0.293	0.607	0.976	1.484	1.907	2.698
85	0.000	0.145	0.292	0.604	0.971	1.476	1.897	2.684
90	0.000	0.144	0.291	0.602	0.967	1.470	1.889	2.672
95	0.000	0.144	0.289	0.599	0.963	1.464	1.881	2.661
100	0.000	0.143	0.288	0.597	0.959	1.458	1.874	2.651
150	0.000	0.139	0.281	0.581	0.934	1.424	1.831	2.601
200	0.000	0.137	0.277	0.573	0.920	1.402	1.802	2.557
250	0.000	0.136	0.274	0.567	0.911	1.388	1.783	2.529
300	0.000	0.135	0.272	0.563	0.904	1.377	1.770	2.508
400	0.000	0.134	0.269	0.557	0.895	1.363	1.751	2.481
500	0.000	0.133	0.267	0.554	0.889	1.354	1.739	2.463
600	0.000	0.132	0.266	0.551	0.884	1.347	1.730	2.449
700	0.000	0.132	0.265	0.549	0.881	1.342	1.723	2.439
1000	0.000	0.131	0.263	0.545	0.874	1.332	1.709	2.419
∞	0.000	0.126	0.253	0.524	0.842	1.280	1.645	2.327

APPENDIX 5

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