NOVA SCOTIA
Environment and Labour

PROCEDURE

DISTRIBUTION SYSTEM - ADDRESSING LOW CHLORINE RESIDUALS

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1. Preamble

The water distribution system is the last protective barrier before a consumer's tap that needs to be operated and maintained to prevent contamination of water. To ensure delivery of high quality water to each consumer, water utilities must be continually vigilant to any intrusion of contamination or occurrences of microbial degradation in the system. Water in a distribution system must be seen as a perishable product that has a shelf life, packaging and a preservative.

- *Shelf life* is the time that the water spends in the distribution system prior to being drawn-off at a consumer's tap;
- *Packaging* is the piping and storage facilities used to convey the water; and
- *Preservative* is the presence of a disinfectant residual, usually free chlorine.

To avoid water quality problems, water utilities must:

- maintain positive pressures and fire flows;
- manage water age;
- maintain a chlorine residual;
- keep the distribution system clean;
- provide treatment that does not allow water to degrade in the system; and
- monitor water quality.

To preclude water quality problems, maintenance of water distribution systems must regularly address all of these aspects.

This procedure focuses on maintaining a chlorine residual and the corrective action to address low chlorine residual levels for municipal water systems.

2. Municipal Responsibility

Municipal drinking water systems are regulated through their Approval to Operate, compliance with the *Water and Wastewater Facilities and Public Drinking Water Supplies Regulations* made pursuant to the Environment Act and the provisions of the *Guidelines for Monitoring Public Drinking Water Supplies*. Treatment standards have also been developed to comply with the *Guidelines for Canadian Drinking Water Quality* for protozoa and viruses.

Section 4.3.1 of the *Guidelines for Monitoring Public Drinking Water Supplies* (Disinfection Residual) states:

> *"A disinfection residual should be continuously maintained throughout the entire water works system. Where a chlorine disinfection system is being used, the goal for free chlorine residual at distant points in a water works system should be a minimum 0.2 mg/L."*

Please note that the minimum free chlorine residual goal of 0.2 mg/L is mandatory for municipal drinking water systems as it is stipulated in the Approvals to Operate. Furthermore, the minimum free chlorine residual requirement has been increased to 0.4 mg/L in Approvals to Operate for the following municipal drinking water supplies:

(a) surface water supply with no treatment other than disinfection;

(b) surface water supply with inadequate or malfunctioning treatment as determined by the regional engineer; or

(c) groundwater supply that can not meet the *Groundwater Treatment Standard* as determined by the regional engineer.

Municipal approvals also require that all incidents of free chlorine residual below the stipulated amount in the distribution system (e.g. 0.2 mg/L or 0.4 mg/L) must:

a) be documented with description of any actions taken and reported to Nova Scotia Environment and Labour (NSEL); and

b) be recorded and the records kept for a minimum of five years.

Staff should refer to the specific municipal Approval to Operate to confirm free chlorine residual requirements. The Approval to Operate will take precedence over the *Guidelines for Monitoring Public Drinking Water Supplies*.

3. Why is a Chlorine Residual Required?

Maintenance of a chlorine residual in the distribution system is intended to provide a persistent disinfectant in order to protect the water from microbiological re-contamination, reduce bacterial re-growth and biofilm formation, and to serve as an indicator of the distribution system integrity. Ensuring the presence of a chlorine residual in the distribution system is the last remaining barrier that prevents the re-contamination of water before the customer consumes the water, making this a critical component of public health protection.

The minimum free chlorine residual requirement of the Approval to Operate has been established to provide a level of confidence in the safety of the water. Routine monitoring of disinfectant residuals provides valuable information about the overall condition of the distribution system. A chlorine residual in any portion of the distribution system that is lower than required may indicate poor water quality and/or an excessive disinfectant demand. This may be the result of any of the following conditions:

- the age of the water in the system since it was treated;
- microbial re-growth within the distribution system;
- reaction with corrosion byproducts;
- cross-connection or other contamination that consumes the disinfectant.

4. Addressing Low Chlorine Residuals

There may be times when the required level of free chlorine residual in a distribution system is not met. If a low residual is observed at one or more of the approved sampling locations, the following actions should be taken to return the chlorine residual to a compliance level:

- Verify the result by re-testing;
  - If re-testing indicates an acceptable residual above the requirement, then there is no need for further action.
- If re-testing indicates the free chlorine residual remains lower than the level required, the owner shall increase the chlorine dosage and/or flush lines until the residual is returned to an acceptable level.
  - The owner must notify NSEL of the situation and continue actions to try to achieve and/or maintain a residual within compliance of the facility approval.
  - Once the test results indicate that the residual has been returned to a compliance level, return to normal operation following discussion with NSEL.

- If chlorine residual test results continue to indicate a residual that is not in compliance with the facility approval, the owner must notify NSEL and prepare an action plan advising what other actions are required, complete with a proposed timeline for implementation. For example, a permanent continuous blow-off station or residual booster station may be required. Consideration may also be given to increasing the frequency of testing for coliform bacteria and/or heterotrophic plate count (HPC) at locations that experience chronic low chlorine residuals. A sudden increase in HPC can serve as an early warning of water quality deterioration.
  - The action plan must be acceptable to NSEL.

- If it is determined that gross contamination of the distribution system has occurred due to a cross-connection, etc., a boil water advisory may be necessary.
  - The Boil Water Advisory requirements are detailed under Sections 4.5 and 4.6 of the *Guidelines for Monitoring Public Drinking Water Supplies*.
  - The owner will also be required to continue actions to eliminate the source of contamination and to achieve a chlorine residual compliance level.

- All residual analyses and corrective actions are to be documented and provided to NSEL upon request.

5. Summary

Nova Scotia Environment and Labour is committed to providing effective regulatory oversight of municipal drinking water systems based on the continued provision of safe drinking water to all Nova Scotians.

The purpose of requiring a minimum free chlorine residual is that it provides an easily monitored parameter for indicating water quality in the distribution system. The minimum concentration values stated in the facility approvals are consistent with industry standards for addressing water quality and safety.

Utilities should have standard operating procedures (SOPs) in place to:

- understand and verify why the chlorine residual in the water distribution system is changing;

- notify NSEL when the level drops below the level required in their Approval to Operate;

- take corrective action(s) to increase the chlorine residual to the level required in their Approval to Operate;

- address a contamination event due to a cross-connection, etc.

Additional information is provided in Appendix ‘A’ (Maintaining Distribution System Water Quality) and Appendix ‘B’ (Flushing Practices) to assist utilities in preparing SOPs to maintain drinking water quality in the distribution system. This information is available in a guide format for distribution to the facility owners/operators.

Dated: July 25, 2005 ______________________________

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Appendix 'A' - Maintaining Distribution System Water Quality

A publication produced by the American Water Works Association Research Foundation (AWWARF) - *'Guidance Manual for Maintaining Distribution System Water Quality'* - serves as the industry-recognized standard, which utilities can use to optimize water quality in a distribution system. The document outlines best management practices (BMPs) in a 5-step protocol. These practices have been widely implemented at utilities throughout North America.

Step 1 Understand your distribution system and define the problems

Distribution system water quality concerns can be attributed to:

- chemical/microbiological reactions within the bulk water;
- chemical/microbiological interactions between the bulk water and piping materials;
- introduction of sediment, silt, sand, turbidity, tastes, odour, colour and organisms from the source water;
- chemical/microbiological interaction between the bulk water and silt/sediments, etc.;
- direct chemical/microbiological intrusion into the distribution system.

Step 2 Set water quality goals and establish preliminary performance objectives

To maximize distribution system water quality relative to safety and consumer satisfaction, all water utilities should have an effective water quality monitoring program in place. At a minimum, the program should:

- provide regular information about the source water quality;
- ensure that finished water entering the distribution system meets all applicable standards for disinfection and turbidity and is treated to minimize corrosion at the consumer's tap;
- monitor distribution system water quality at the frequency prescribed and look for signs of water quality deterioration;
- monitor secondary parameters, such as pH, temperature, alkalinity, turbidity and colour, throughout the distribution system to evaluate changes in water quality due to contact with distribution system materials and extended water age;
- be responsive to source water changes, treatment upsets and events in the distribution system that may impact safety, quality, or quantity.

Once a sampling plan is established, water quality goals for monitored parameters should be established. Utilities may also establish goals for the aesthetics of water at the consumer's tap in an attempt to reduce complaints and increase customer satisfaction. The utility should then establish specific performance standards to help meet the water quality goals (e.g. minimum pressure of 20 psi, minimum residual of 0.2 mg/L, maximum water age of 3 days, etc.).

Step 3 Evaluate alternatives and select the best approach

This step uses the information from Steps 1 and 2 to develop, evaluate and select the preferred approach to address water quality problems. Each of the pathways noted in Step 1 can be addressed to some degree through practices related to monitoring, operations, maintenance, engineering, and/or management. Depending on the type of water quality problem, the most appropriate solution may require changes in operations or maintenance practices, additional monitoring or an engineered solution at the source or within the distribution system.

It is important to note that distribution system operation and maintenance activities only help to maintain water quality conditions in the distribution system. As such, adequate source treatment is the first step towards improving distribution system water quality. Treated water should ideally be non-corrosive, chemically stable, non-scaling and should be free of pathogenic organisms. The water should also be stable from a microbiological standpoint to minimize the growth potential in the system. This generally means that the organic content should be low and that the water should be biologically stable.

In addition, pH instability, which results in pH fluctuations in the distribution system, causes problems because metallic piping and aging scales exposed to varying or cyclical pH conditions are more susceptible to metal release and precipitation when compared with more stable conditions. Rapid or extensive pH fluctuations may also trigger microbial changes and releases into water.

Step 4 Implement good management practices and monitor effectiveness

This step puts the recommended plan from Step 3 into action. Operating practices should be implemented to minimize the water's age, maintain positive pressure and control the direction and velocity of the water. It is important to minimize the age of the water in the distribution system because reactions within the bulk water and between the bulk water and piping materials causes water quality degradation. It is very important to maintain positive pressures throughout the system to ensure the backflow of contaminants does not occur. Various codes of good practice and manuals suggest 20 psi as a minimum pressure to maintain under extreme operating conditions such as fire flows. Utilities should also attempt to minimize rapid and/or extreme fluctuations in flow velocities and should minimize the frequency of flow reversals. These types of changes can scour sediments and bring particles into the water causing water quality deterioration.

Additional good management practices include:

- implementation of a cross connection control program - to minimize the possibility of chemical or microbiological contamination;

- implementation of a leak detection and repair program - leaks may serve as an entry point for contaminants when pressure drops in the system, in addition to contributing to excess water losses.

Maintenance procedures include system flushing and cleaning. Flushing helps to remove stagnant water and to remove unwanted contaminants that may have inadvertently entered the system. Flushing can also keep the system free of sediment if sufficient cleansing velocities are achieved. Cleaning techniques include mechanical scraping, pigging, swabbing, chemical cleaning and flow jetting. Each technique has its benefits and drawbacks and should be tailored to the specific problem. More information on flushing is provided in Appendix 'B' (Flushing Practices).

Normal utility maintenance activities also include conducting emergency pipe repairs with sanitary precautions in place. This includes keeping contaminated water out of a trench and from entering the pipe as much as possible, flushing the line in the vicinity of the break, applying disinfectant to the components that were potentially contaminated and conducting bacteriological testing of the water to confirm the absence of contamination. Sanitary practices are also necessary in the construction and release of new watermains. Disinfection practices should follow AWWA Standards.

Utilities should also have regard for water quality during system design. Dead end pipelines should be avoided or precautions taken to minimize water age (e.g. flushing, blow-offs, etc.) Pressure zones should be planned or configured to reduce water age and maintain water quality.

Step 5 Finalize performance standards and develop standard operating procedures

This step requires the utility to develop standard operating procedures (SOPs). The preliminary performance standards proposed in Step 2 should be re-visited and changed if needed to reflect lessons learned during implementation. SOPs should be developed for each operation and maintenance function that affects system water quality, including but not limited to storage facility inspection/maintenance/operation, flushing programs, disinfection of mains, disposal of chlorinated water, etc.

The water quality goals for the distribution system and the goals for the particular function should be specifically described in the introduction of the SOP. The SOPs should include all activities needed to conduct the procedure. Standard details, tables, drawings, pictures and forms should be part of the SOP to illustrate and clarify the specific activities. The SOPs should also describe the labour, equipment and materials needed to complete the activities. Work preparation steps, actual work steps, and work completion steps should be clearly outlined and described. The activities should be periodically reviewed and modified based on input received from all affected groups to ensure SOPs remain accurate, beneficial and easy to follow.

Management should work with distribution staff to develop and implement written SOPs. This will help staff know what is expected of them, can serve as a basis for training and can help pass down knowledge from experienced staff to those who are assuming increased responsibility.

Appendix 'B' - Flushing Practices

Effective flushing practices are identified as key for maintaining water quality and for addressing water quality concerns in most municipal distribution systems. The *Guidance Manual for Maintaining Distribution System Water Quality* as published by the AWWARF identifies a 4-step flushing program.

Step 1 Determining the Appropriateness of Flushing as Part of a Utility Maintenance Program

The guidance manual recommends that when a system experiences difficulty in maintaining a disinfectant residual in portions of the distribution system, it is recommended that a flushing program be put in place.

Step 2 Planning and Managing a Flushing Program

A site-specific program will address water quality concerns and minimize unnecessary costs. There are several types of acceptable methods including:

- *Unidirectional Flushing* – often used to remove biofilm and corrosion products by applying a minimum flushing velocity of 1.83 metres/second. Lower velocities can be used to restore chlorine residual. This method can achieve water savings of greater than 40% compared to 'conventional flushing'.
- *Conventional Flushing* – normally the method of choice as it needs little or no pre-design/engineering when compared to 'unidirectional flushing'. Also, this method requires less planning than unidirectional flushing so it can be more quickly implemented to address low chlorine residual concerns.
- *Continuous Blow-Off* – commonly implemented at systems that have numerous dead-ends and water circulation problems. Blow-offs can be installed with automation, which lessens the labour requirements compared to other flushing methods.

Step 3 Implementing a Flushing Program and Data Collection

Implementation of a flushing program may include a number of parameters to be addressed, such as:

- determining flushing velocity requirements;
- developing standard operating procedures;
- addressing public and employee safety concerns/issues;
- public notification requirements;
- data collection and management;

- reporting requirements.

Step 4 Evaluating and Revising a Flushing Program

Evaluating a flushing program allows the municipality to properly adjust their specific program. Determining whether the type of flushing and the procedures used were effective in meeting the objectives of the program will assist managers in making any necessary revisions to their program.