Training Manual for Supervised Persons Conducting Operational Checks

• Ministry of the Environment •

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Training Manual for Supervised Persons Conducting Operational Checks

Portions of this manual are reproduced from "Operation of Small Drinking-Water Systems- A Correspondence Course for Non-Municipal Drinking-Water System Operators" and the "Entry-Level Drinking-Water Operator's Training Course Self-Study Guide," both published by the Ministry of the Environment.

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1. INTRODUCTION

Amendments made June 2006 to Ontario Regulation 170/03 – *Drinking Water Systems Regulation* (O. Reg.170/03), allow persons other than a certified operator, trained person or water quality analyst to conduct (using portable or hand-held analyzers) chlorine residual and turbidity tests required under Schedules 7, 8 and 9, provided that certain conditions are met.

These amendments apply to the following categories of O. Reg. 170/03 drinking-water systems:

Small Municipal Residential

Large Municipal Non-Residential *serving designated facilities*

Small Municipal Non-Residential *serving designated facilities*

Non-Municipal Year-Round Residential

Non-Municipal Seasonal Residential *serving designated facilities*

Large Non-Municipal Non-Residential *serving designated facilities*

Small Non-Municipal Non-Residential *serving designated facilities*

The amendments will allow a person who is not a certified operator, trained person or water quality analyst to conduct the chlorine residual and turbidity tests as long as the person:

a) has been trained by a certified operator to conduct the test,

b) works under the supervision of a certified operator, and

c) immediately advises a certified operator of all test results.

The purpose of this manual is to provide guidance for certified operators who intend to train a person to conduct chlorine residual and turbidity sampling and testing. A secondary focus of this material is to provide general guidance on the taking of samples that are destined for analysis by licensed laboratories which typically include both microbiological and chemical samples. This information is provided as there are no regulatory requirements regarding the qualifications of a person taking microbiological and chemical samples and the certified operator may ask a supervised person to perform these tasks.

Important Notes - Restrictions to Supervised Person's Responsibilities:

- Supervised persons who conduct chlorine residual and turbidity checks may do so only if they are conducting these checks with portable or hand-held analyzers. A supervised person may not conduct these tests if the testing entails the use of laboratory or bench analytical methods, or use, in the case of chlorine residual analysis, an amperometric titrator.
- Supervised persons who conduct chlorine residual and turbidity checks are not authorized to interpret or analyze the results. Section 6-5 of Schedule 6 requires that if a drinking water system is required to conduct testing using a continuous analyzer, a certified operator or a trained person must examine the test results within 72 hours after the tests are conducted.
- Supervised persons may only perform chlorine residual and turbidity checks at the sample locations described under Schedules 7, 8, and 9 of O. Reg. 170/03.
- Supervised persons may not conduct other operational checks such as fluoride concentration tests.
- All systems subject to O. Reg. 170/03 still require a certified operator or trained person to operate the system.
- A supervised person may not be used in large municipal residential systems.

1.1 DISCLAIMER

This manual summarizes regulatory requirements made under the *Safe Drinking Water Act* (the Act). Users of this manual are advised to refer to the Act, and the regulations made under the Act, in their entirety. All Ontario statutes and regulations may be viewed on the government's e-laws web site at:

www.e-laws.gov.on.ca

1.2 GENERAL TERMS

The following terms will be used to describe persons with various levels of training.

Supervised person:

For the purpose of this manual the person trained by a certified operator to conduct discrete (grab) chlorine residual and turbidity testing will be referred to as a "supervised person".

Certified operator:

> A "certified operator" is an individual who holds or is deemed to hold a certificate (water treatment, water distribution, or water distribution and supply) under O. Reg. 128/04 made under the *Safe Drinking Water Act* applicable to the type of subsystem that they are working in, but does not include an individual who holds, or is deemed to hold, a water quality analyst's certificate.

Trained person:

> A "trained person" is:
>
> (a) a certified operator, or
>
> (b) a person who, in the preceding 36 months, successfully completed a course approved by the Director that relates to the operation and routine maintenance of a drinking-water system.

Water quality analyst:

> A "water quality analyst" is a person who holds a water quality analyst's certificate issued under section 16 of O.Reg. 128/04 or who holds a conditional water quality analyst's certificate under section 17.

2. TIPS FOR THE TRAINER

This manual contains general information and procedures about conducting chlorine residual and turbidity checks.

When training the supervised person, in addition to the general information in this manual, the certified operator must refer to the instruction manual provided by the manufacturer of the particular testing equipment being used.

2.1 Provision of Background Material

It is recommended that the certified operator provide background information that will provide the supervised person a context that will make their work meaningful, and that will provide an understanding of the importance of collecting samples. Examples of the level of background information (for example, disinfection) are provided throughout the manual. The manual should be kept and used as a reference by the supervised person.

2.2 Supervised Practice Tests

The supervised person must demonstrate to the certified operator their ability to perform chlorine residual and / or turbidity tests following the instructions provided by the manufacturer. It is suggested that before the supervised person conducts sampling and testing independently, the certified operator oversee several hands-on 'practice sessions' with the equipment that is to be used in the field. In addition, the certified operator must leave a copy of the manufacturer's instructions with the supervised person.

2.3 Contact Lists & Field Equipment

The certified operator should provide the supervised person with comprehensive contact information which includes the names and contact numbers (including after-hours) of the certified operator and appropriate alternates before the supervised person proceeds with their sampling duties.

A certified operator must always be available for contact by the person conducting the tests. This requirement is important because a supervised person is not authorized to interpret the test results. A certified operator must be available to interpret the results immediately after the results are available so that in the event of an adverse test result or other problems, the certified operator could immediately notify the Ministry of Environment (the ministry or MOE) Spills Action Centre and the local Medical Officer of Health (MOH), and if applicable, the interested authority for the designated facilities connected to the system.

2.3.1 Contact Information

This is a sample of the type of contact information that could be provided to the supervised person before he/she begins sampling duties.

Contact Information

Name of certified operator: _____
Office Phone: _____
Home Phone: _____
Cell Phone: _____

Equipment Manufacturer: _____
Telephone Number: _____

Calibration Technician: _____
Telephone Number: _____

Reagent Supplier: _____
Telephone Number: _____

Distribution system
sample contact(s): _____
(if private residences)
Telephone Number: _____

MOE Spills Action Centre 1-800-268-6060
(For reporting adverse results, water quality results, and to contact Ministry of Labour after-hours)

Local Health Unit: _____

2.3.2 Equipment & Materials Checklist

It is suggested that the certified operator ensure that the supervised person has access to the following types of information, equipment and tools before being sent out to sample.

Materials Checklist

- ☑ **Contact Sheet**
- ☑ **Copies of manufacturer's instructions (certified operator or system owner keeps the original) in protective sleeve or laminated**
- ☑ **Site-specific sampling instructions (sample type and schedule)**
- ☑ **Sampling instructions from licensed laboratory**
- ☑ **Map or list of sample locations, especially distribution system locations**
- ☑ **Standard Operating Procedures**
    - o **How to relay test results**
    - o **How to contact certified operator**
    - o **Other information to collect and record when taking operational tests**
- ☑ **Primary equipment (chlorine analyzer, turbidimeter)**
- ☑ **Secondary equipment:**
    - o **Batteries (including extras)**
    - o **Extra DPD reagent pillows/ampules; extra cuvettes**
    - o **Calibration log with date of next calibration**
    - o **Scissors (to cut open reagent packets)**
    - o **Laboratory tissues "Kimwipes"**
    - o **Extra sample bottles from licensed laboratory Gloves**
    - o **Waterproof pen; log/sheet & protective cover**
    - o **Chain-of-Custody forms**
    - o **Carry case, padding, ice packs**
    - o **Bench – some distribution sampling places have no counters**
    - o **Keys to gates, buildings etc.**

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3. BASIC OBJECTIVES OF MONITORING

Monitoring is an important step in providing safe drinking water. Drinking water is monitored for several reasons:

- To provide a level of assurance that the drinking water supplied by a drinking-water system is safe to drink;
- To meet regulatory requirements;
- To determine changes in the quality of source water (these changes will help to operate the system efficiently in the future);
- To determine the effectiveness of the treatment process, especially disinfection;
- To provide information on the integrity of the distribution system;
- To provide information necessary to control treatment processes (for example, adjust chemical solution strength, chemical feed pump rate, etc.);
- To document the quality of the water supply; and
- To enable proper response to customer complaints.

Monitoring can be differentiated as follows:

- Regulatory monitoring – testing and sampling required by regulations, MOE orders or Certificates of Approval. Regulatory monitoring includes:
  - Operational Checks (see Schedules 7, 8 and 9 of O. Reg. 170/03)
  - Microbiological Sampling and Testing (Schedules 10, 11, and 12)
  - Chemical Sampling and Testing (Schedules 13 and 15)
- Non-Regulatory operational monitoring – in-house monitoring to optimize performance, chemical addition, etc, when changes in raw water conditions occur.

4. ADVERSE RESULTS

The supervised person is required to immediately advise the certified operator of the results of all chlorine residual and turbidity tests that he or she conducts. This is especially important in a situation where an adverse water quality test is obtained, so that the person (or alternative) who is appointed by the owner or operating

authority is able to immediately report the adverse result as required by the *Safe Drinking Water Act* (the Act) and Schedule 16 of O. Reg. 170/03.

The Act and the regulation require that adverse test results and observations indicting inadequate disinfection must be reported by the owner or operating authority to a person at the MOE Spills Action Centre (SAC) and to a person at the office of the local Medical Officer of Health (MOH) immediately after the adverse result is obtained, and by written notification (e.g. fax) within 24 hours. The specific details concerning what is considered an adverse test result for chlorine residual and turbidity testing, and details about the reporting process will be discussed later in section 14 of this manual.

5. QUALIFICATIONS REQUIRED

Operational checks for chlorine residual and turbidity must be conducted on-site rather than being transported to a licensed laboratory for testing. This is because chlorine residuals deteriorate rapidly, and because the suspended material causing turbidity could settle out or change by the time the sample reaches the laboratory and thereby skew the test results. For these reasons, the regulation allows for and requires chlorine residual and turbidity testing to be conducted on-site by qualified personnel.

On the other hand, all water samples collected for the required microbiological and chemical tests must be analyzed by a licensed laboratory. Any person is allowed to collect and transport samples to the licensed laboratory as long as the samples are taken and handled in accordance with the directions of the licensed laboratory that will be conducting the testing (see section 6-8, Schedule 6 of O. Reg. 170/03). O. Reg. 248/03 (*Drinking Water Testing Services*) requires licensed laboratories to provide this information to drinking-water system owners and operators.

The following table (1) summarizes the type of regulatory samples that must be taken under O. Reg. 170/03 and shows the minimum qualifications of the person who is allowed to take the sample, and who can conduct the analysis.

Table 1 Qualifications Required to Conduct Operational Checks, Sampling & Testing Required under O. Reg. 170/03

Drinking-Water System Category	Operational Checks[2] (Schedules 7, 8, 9) (Chlorine Residual[1], Turbidity[1]	Microbiological Samples[3] (Schedules 10, 11, 12) Chemical Samples (Schedules 13 and 15)	
		Sample Taking and Transport	Sample Analysis
Systems under Schedule 7 Operational Checks			
Large Municipal Residential	Certified Operator, Water Quality Analyst	No qualifications required, but must follow instructions provided by licensed laboratory (per section 6-8, Schedule 6 of O. Reg. 170/03)	Must be analyzed by a licensed laboratory (section 63, SDWA; O. Reg. 248/03)
Small Municipal Residential	Certified Operator, Water Quality Analyst, Supervised Person (subsection 7-5 (1.1), Schedule 7 of O. Reg.170/03)	<as above>	<as above>
Systems under Schedule 8 Operational Checks			
Large Municipal Non-Residential *serving designated facilities*	Certified Operator, Water Quality Analyst, Supervised Person (subsection 8-5 (1.1), Schedule 8 of O. Reg. 170/03)	<as above>	<as above>
Non-Municipal Year-Round Residential		<as above>	<as above>
Large Non-Municipal Non-Residential *serving designated facilities*		<as above>	<as above>
Systems under Schedule 9 Operational Checks			
Small Municipal Non-Residential *serving designated facilities*	Certified Operator, Water Quality Analyst, Trained Person, Supervised Person (subsection 9-5(1.1), Schedule 9 of O. Reg. 170/03)	<as above>	<as above>
Non-Municipal Seasonal Residential *serving designated facilities*		<as above>	<as above>
Small Non-Municipal Non-Residential *serving designated facilities*		<as above>	<as above>

[1]Supervised persons may only conduct chlorine residual and turbidity tests using portable or hand-held testing kits or devices. Supervised persons may not conduct laboratory/bench analyses for chlorine residual and or turbidity. See section 1 (Introduction) of this manual for other restrictions.
[2]Supervised persons may not conduct any other operational checks required by the regulation (e.g. fluoride concentration testing).
[3]A sample must be taken at the same time and from the same location as every microbiological sample required by regulation, Order or Certificate of Approval, and tested immediately for chlorine residual (section 6-3, Schedule 6). This does not apply to sampling conducted by microbiological in-line testing equipment. See Operational Checks column for qualifications required.

6. TYPES OF SAMPLES

There are two types of samples which may be required to be collected at a drinking-water system.

1. **A grab or discrete sample** is an individual sample of water taken at a particular time and location. Grab samples are required for all tests required under the regulation except where a particular test is required or permitted to be conducted by continuous monitoring equipment.

2. **Continuous monitoring** equipment or analyzers are devices that continuously and directly measure the level of a parameter in water or automatically take periodic samples of water and individually test them using in-line automatic testing equipment. The continuous monitoring equipment used for the monitoring of parameters required under O. Reg. 170/03 must also automatically record the test results and sound alarms when limits are exceeded. The parameters that under O. Reg. 170/03 are permitted, and in some system categories and specific cases required, to be monitored by continuous monitoring equipment include chlorine residual, turbidity , and fluoride concentration.

7. OPERATIONAL CHECKS - CHLORINE RESIDUAL TESTING

7.1 General Concepts of Disinfection

Disinfection is a chemical or physical process used to inactivate (kill or make incapable of reproducing) harmful or disease-causing micro-organisms called pathogens, in water. *E. coli* is one example of a pathogen, which was responsible for the fatalities in Walkerton.

Under O. Reg. 170/03 all drinking-water treatment systems must provide "primary disinfection" which typically occurs at a water treatment plant, and must be completed before the drinking water enters the distribution system. In some cases, point-of-entry treatment units may be used for primary disinfection, which must be completed by the time water leaves the units. There are also exemptions from treatment requirements for certain non-municipal year-round residential systems that do not serve designated facilities and that can demonstrate a history of good ground water quality. Drinking-water systems that take their raw (untreated) water from a surface water source such as a river or lake must also provide filtration.

Commonly used chemical disinfectants are chlorine-based chemicals such as chlorine (gas), chloramine, chlorine dioxide and sodium hypochlorite. Ozone is

another chemical sometimes used as a disinfectant. Chemical disinfectants inactivate pathogenic micro-organisms by breaking down their cell walls and causing them to rupture.

The most commonly known physical disinfectant is ultra-violet radiation (UV). It is believed that UV rays penetrate the cells of the micro-organisms and damage internal cell parts that are vital in reproduction and general metabolism.

Under the SDWA and its regulations, drinking-water systems that have distribution systems (pipes that transmit water and storage structures such as reservoirs) must normally also provide a form of disinfection called "secondary disinfection". Secondary disinfection is intended to ensure that harmful pathogenic micro-organisms do not regrow and recontaminate treated water as it is being transported to consumers' taps. In Ontario, only chlorine-based disinfectants - specifically chlorine, chlorine dioxide and monochloramine (chloramine) - may be used because of chlorine's ability to persist (not dissipate, change or deteriorate) within a distribution system.

Note: The requirement to provide secondary disinfection is described under sections 1.5 and 2.5 of Schedules 1 and 2 of O. Reg. 170/03. However, categories of systems which install point-of-entry treatment units and meet the conditions described under Schedule 3 may not be required to provide secondary disinfection. Similarly, there are exemptions from secondary disinfection requirements for certain non-municipal year-round residential systems that do not serve designated facilities and can demonstrate a history of good ground water quality.

7.2 What Chlorine Residual Is

When chlorine is added to untreated water, the chlorine reacts with impurities that are dissolved or suspended in the water such as certain minerals and organic matter. The amount of chlorine that is needed to combine or react with all these impurities is the "chlorine demand".

The concentration of chlorine that can still be measured in water after the added chlorine has reacted with the impurities present in water is called the available chlorine residual concentration. Only the available chlorine residual is capable of pathogen inactivation (disinfecting).

The presence of chlorine residual in drinking water may indicate that:

a) a sufficient amount of chlorine was added initially to the water to inactivate disease-causing micro-organisms (such as bacteria), and

b) that the water is protected from recontamination during distribution and storage.

7.2.1 Why Chlorine Residual is Monitored

There are many reasons why monitoring chlorine residual is important:

1. To ensure that a sufficient amount of chlorine was added initially to the water to inactivate disease-causing micro-organisms (such as bacteria and viruses),

2. To ensure that there is a sufficient amount of chlorine to protect the water from recontamination during distribution and storage,

3. To ensure levels are high enough to improve the taste & odour of drinking water,

   Chlorine can improve the quality of finished water by reacting with ammonia, iron, manganese, sulphide, and some taste and odour producing substances.

4. To ensure that chlorine levels are not too high,

   Chlorine can also produce undesirable effects by reacting with naturally – occurring substances to form undesirable disinfection by-products that may have adverse health effects. Excess chlorine can also cause taste and odour problems.

5. For process control purposes:

   a) To provide information necessary to compensate for changes in raw water that affect chlorine demand.

      The amount of chlorine-based disinfectant that a system requires can change from day to day, especially with surface water systems, because of changes in the temperature, pH and chlorine demand. Chlorine demand is the amount of chlorine that is 'used up' when it combines with impurities in the raw water.

   b) To make sure that chlorine injection (feed) equipment is working properly or is properly calibrated.

For all of the above reasons, it is necessary to accurately and regularly monitor chlorine residuals to ensure public health protection.

Because chlorine residual decays rapidly, immediate on-site testing of the samples is required by a properly qualified individual rather than testing by a licensed laboratory.

7.2.2 Chlorination and the Measurement of Free Chlorine Residual

The most commonly accepted chemical disinfection method is through the use of free chlorine. Disinfection through the use of free chlorine is called is called chlorination.

The "free chlorine" that provides disinfection in the chlorination process can come in the form of dissolved chlorine gas, hypochlorous acid, or hypochlorite ions that are formed when chlorine is added to water that contains little or no ammonia, ammonium ions or organic nitrogen. Free chlorine chlorination is usually achieved through the addition of chlorine gas, sodium hypochlorite, calcium hypochlorite, and sometimes through the use of a free chlorine-producing electrochemical process.

The type of chlorine residual that must be measured in systems where chlorination is provided is “free chlorine” residual.

7.2.3 Drinking-Water Systems that Provide Disinfection through Chloramination

Few systems in Ontario, other than large municipal residential systems, provide disinfection through chloramination. See Appendix 1 for further information about the type of chlorine residuals that must be measured or calculated for systems that chloraminate, and how to test for them.

7.3 Units of Measurement

Chlorine residual concentrations referred to in O. Reg. 170/03 are expressed in milligrams per litre (mg/L). Chlorine residual records should therefore be recorded in terms of mg/L.

7.4 Location and Frequency of Chlorine Residual Checks

Schedules 7, 8 and 9 of O. Reg. 170/03 require the testing of treated water and distribution system samples for chlorine residual through grab (discrete) sampling, or the use of continuous chlorine residual analyzers. Chlorine residual samples must be collected and tested from the location(s) or point(s) and at a frequency required by the regulation for the particular system.

These regulatory requirements are different for different system categories. It is the responsibility of the certified operator to provide the supervised person with detailed instructions regarding the sampling locations, schedules and the methods of testing for the system where the supervised person is employed to collect samples and perform the chlorine residual tests.

7.4.1 Sampling Location for Systems which provide Primary Disinfection through Chlorination or Chloramination

Drinking-water systems that provide primary disinfection through chlorination or chloramination are required to take treated water samples (or monitor the chlorine residual using continuous analyzers) in the treatment process at or near a location where the intended “contact time” has just been completed, in accordance with the ministry’s *Procedure for Disinfection of Drinking Water in Ontario* (see Schedules 7, 8, and 9 of O. Reg. 170/03).

7.4.2 Sampling Locations for all O. Reg. 170/03 Categories with a Distribution System

Schedules 7, 8, and 9 of O. Reg. 170/03 require that systems which provide secondary disinfection must take chlorine residual distribution samples. The regulation definition of "distribution samples" indicates that the sample must be taken “from a point significantly beyond the point at which the drinking water enters the distribution system or plumbing” (subsection 1(1) of O. Reg. 170/03).

Distribution samples must be representative of the whole system and taken from locations that are typical for the system. Distribution samples can be taken from distribution lines, but they also can be taken from plumbing lines or fixtures where these locations are typical of the system. Some system owners make arrangements with residents so that samples may be taken from consumers' taps. Some municipalities have dedicated outdoor sampling stations.

7.5 DPD Method of Conducting Chlorine Residual Testing

There are three common chlorine residual testing methods:

- DPD Test (using commercial comparators, i.e. hand-held or portable analyzers)
- Amperometric titration (on-site comparative analysis)
- Continuous residual analysers

Note: The amperometric titration method and the use of continuous residual analyzers are not discussed further in this manual for the following reasons. The Amperometric titration method is a comparison test for determining free or combined chlorine residual, and requires greater operator skill than the DPD method to obtain good results. If testing through the use of a continuous analyzer is conducted or required to be conducted, Section 6.5 of Schedule 6 requires that a certified operator or trained person must examine test results within 72 hours after the test is conducted; a supervised person may not interpret or respond to the results provided by continuous analyzers.

7.5.1 Analytical Principles of the DPD Method

The DPD method is a simple test designed for field or laboratory determination of free and total chlorine in water using a chemical (or reagent) called N,N-diethyl-*p*-phenylenediamine (DPD) as the colour indicator. DPD produces a pink colour to a degree proportional to the chlorine content of the water. The colour of the water is compared with the standard colour scale in the instrument to determine the chlorine content of the water. This is done automatically by the DPD testing instrument which is called a colorimeter or colour comparator.

Depending on the type of DPD test kit, the DPD reagent may be in the form of a tablet, powder (in a powder 'pillow') or solution (in a foil ampule). When added to water, DPD will turn the water from light to dark pink depending on the amount of chlorine residual in the water.

7.5.2 DPD Comparator Parts & Reagents

A colour comparator kit typically comes with complete colour viewing tubes, and caps. Older comparators may have a standard colour scale (disks or coloured blocks) to compare to the colour of sample "by eye" in order to determine the concentration of chlorine. Models used now make the comparison automatically. Replacements and additional viewing tubes are commercially available, and the supplier may also provide the DPD reagents (for free chlorine and total chlorine) upon initial purchase.

7.5.3 How to Conduct Tests

As with all test methods, the instructions that are provided by the manufacturer must be carefully followed. The test results will only be meaningful if properly conducted. The following information is for general reference purposes only. Where this information contradicts the instructions provided by the equipment manufacturer, those of the manufacturer must be followed.

In the following general procedure, a sample is added to two identical viewing tubes. The indicator or reagent, DPD, is added to one tube to produce a colour change. The tube without the DPD serves as a control tube to ensure accurate colour match by nullifying colour or turbidity in the sample. Most colorimeters automatically 'read' the colour of the sample containing the indicator (or reagent) to determine the chlorine residual concentration. Older colorimeters require the sampler to 'match' the colour of the sample with the DPD reagent with a colour wheel or standard colour tube.

Terms Commonly Used

Manufacturers and suppliers of equipment often call the same thing by different names. To reduce confusion for the supervised person, below are a few terms which may need some clarification:

- A viewing tube may also be called a sample cell or a cuvette or vial.
- The DPD reagent may also be called a DPD indicator.
- A portable chlorine residual analyzer may be called a colorimeter or a colour comparator.

Free Chlorine Determination Procedure (for systems that practice chlorination):

1. Rinse two viewing tubes with chlorine-free distilled water or treated water without reagent. Check the instructions of the manufacturer about the water that is to be used for rinsing & cleaning.
2. Fill the first viewing tube (the control viewing tube) to the graduation mark recommended by the manufacturer with the water to be tested, and place it in the cell compartment.
3. Press the "zero" key and remove the control viewing tube once the instrument confirms that it has been zeroed.
4. Fill the second viewing tube (the sample viewing tube) to the graduation mark with water to be tested.
5. Add the entire contents of the pre-packaged free chlorine reagent to the sample viewing tube. Cap and swirl to mix. (Occasionally, swirling alone

does not produce good precision in data. To solve this problem, shake the sample vigorously for 15 seconds, then swirl to remove air bubbles. The powder does not have to dissolve completely to obtain a correct reading.) Place the sample tube in the sample compartment

6. Press the “read” key. The instrument will automatically conduct the comparative analysis and will display the free chlorine result. . The free chlorine residual must be read within the time recommended by the manufacturer (usually one minute).
7. For instruments which rely on use of a manual colour wheel, hold the comparator to a light source and compare the sample viewing tube to the comparator standard colour scale. When a colour match is achieved, record the free chlorine value in mg/L. The free chlorine residual must be read within the time recommended by the manufacturer (usually one minute).

For systems that provide disinfection through chloramination, total chlorine must be measured. See Appendix 1 for details.

When using the above method, make sure the correct DPD reagent is used; some types of DPD will test for free chlorine residual while others test for total chlorine residual.

7.5.4 Testing Interferences

- **Interferences by other materials:** Substances found in water samples such as iodine, bromine and bromamine, and oxidized manganese (oxidized iron is called rust) will also react with DPD and can affect the results of DPD analysis. For example, oxidized manganese (which can be naturally-occurring or can be added in the form of potassium permanganate as a treatment chemical) will react with DPD to give a pink colour identical to the colour produced when DPD reacts with chlorine. The certified operator should check with the reagent’s manufacturer’s information about such interferences, and should ensure that the supervised person is instructed on how to make corrections recommended by the manufacturer. Some sample kits include inhibitors which may be added to sample sources that are known to contain oxidized manganese.

- **Temperature:** High temperature enables chloramine to appear as free chlorine and increases colour fading. Therefore chlorine residuals must be measured rapidly when surrounding (ambient) temperatures are high.

- **Presence of Monochloramine:** If present in high concentrations, monochloramine interferes in the free chlorine residual determination after 1 minute of developing time. Therefore, all readings must be made within the specified time interval.

- **pH Changes:** The DPD reagent lowers the pH of the sample to a range within 6.2 to 6.5. A lower pH enables chloramine to appear as free chlorine. However a higher pH causes oxygen that is dissolved in the sample to give a pink colour identical to that produced by chlorine.

7.5.5 General Hints and Cautions

The following tips should be followed in order to ensure that test results are accurate.

Cleanliness of Sample & Cuvette (Colour Viewing Tubes or Vials)

- Ensure that the cuvette is clean and unscratched - do not touch the walls of the cuvette. Use gloves or a laboratory tissue when handling and wipe the cuvette clean before inserting it in the cell compartment.
- The cuvette must be completely free of fingertips, oil or dirt, when it is placed into the cell compartment.
- Ensure that the sample does not contain any debris which may interfere with the readings.
- Discard the sample immediately after the reading is taken, otherwise the glass may become permanently stained.

Adding & Mixing the Reagent

- Shaking the cuvette can generate bubbles in the sample, causing higher readings. To obtain accurate measurements, remove such bubbles by swirling or by gently tapping the vial.

Sampling Speed

- Do not let the sample stand too long after the reagent is added, as it will affect the accuracy of the reading.

7.5.6 Calibration

Known amounts of potassium permanganate solution are used as standards to verify the calibration of the comparator standard colour scale used to determine chlorine concentration. The supervised person is not expected to prepare standards using laboratory methods. Prepared standards are available from equipment manufacturers and distributors.

- The DPD colour comparator kit should be calibrated initially when the kit is purchased and thereafter at least once every three months, or according to manufacturer's specifications.

- Colour standards are light sensitive and fade when exposed to sunlight or high temperatures. Expiry dates of standards should be checked.

7.5.7 Zeroing

In order to maintain the same conditions during the zeroing and the measuring phases, a lid should be placed on the cuvette to avoid contamination.

If conducting more than one test in rapid succession, take a zero reading for each sample and use the same cuvettes for zeroing and measurement.

7.5.8 Equipment Cleaning, Maintenance & Storage

Clean with a cotton swab using alcohol or a cleaning solution, as recommended by the manufacturer of the analyzer.

Colour comparators should be stored indoors in a dark, cool location.

The shelf life of DPD reagents is adversely affected when exposed to higher temperatures or direct sunlight. If the contents of the power pillows or tablets are discoloured, they should be discarded.

The colorimeter may be damaged by freezing if stored in a vehicle during the winter. Storing test kits inside vehicles shortens the life expectancy of colour standards.

7.6 Notification of Chlorine Residual Testing Results

One of the requirements under sections 7-5, 8-5, and 9-5 of Schedules 7, 8 and 9 that allow a person who is not a certified operator, trained person or water quality analyst to conduct operational tests is that the person must immediately advise a certified operator of all test results. Note that the regulation specifically states all test results must be relayed to the certified operator immediately. In order to meet this requirement and the requirement for supervision by a certified operator, all efforts must be made to ensure that the supervised person has a direct means to reach the certified operator at all times when he or she is conducting tests on behalf of the certified operator.

7.7 Adverse Chlorine Residual Results vs. Chlorine Residual Targets (for Systems that Provide Chlorination)

As mentioned above, immediate notification of operational test results is particularly critical in the event of adverse chlorine residual results identified in the regulation. The obligations of a drinking-water system owner to report adverse results were introduced under section 4 of this manual; details are provided in section 14.

7.7.1 Secondary Disinfection

The following is prescribed as an adverse result of a drinking water test under section 16-3 of Schedule 16 for systems that chlorinate:

- A result indicating the concentration of free chlorine residual is less than 0.05 mg/L in a distribution sample that is a grab sample, if the system provides chlorination but does not provide chloramination, and an adverse report in respect of free chlorine residual hasn't been made in the previous 24 hours

7.7.2 Primary Disinfection

O. Reg. 170/03 requires that: "an observation which indicates that a drinking-water system is directing water that has not been properly disinfected in accordance with the ministry's *Procedure for Disinfection of Drinking Water in Ontario* to users of the system must be reported". (See section 16-4 of Schedule 16, O. Reg. 170/03).

The *Procedure for Disinfection of Drinking Water in Ontario* (the *Disinfection Procedure*) requires a drinking-water system owner to determine the chlorine residual concentration and contact time that will meet the primary disinfection requirements of the *Disinfection Procedure*. This chlorine residual concentration will vary from plant to plant depending on the characteristics of the raw water, the treatment processes and chemicals used. The certified operator should clearly inform the supervised person of the chlorine residual that is required to achieve primary disinfection in the plant, and the location within the process where contact time has just been completed.

The SDWA and O. Reg. 170/03 require that the above adverse results be immediately reported to the MOE and MOH. See section 14 of this manual for details on reporting of adverse water quality results.

Note: The chlorine residual concentrations described in the above sections describe minimum regulatory requirements. When training the supervised person, the certified operator should be sure to differentiate between these regulatory limits and operational targets that the drinking-water system may have set.

7.7.3 Recommended Maximum Chlorine Residual

The *Procedure for Disinfection of Drinking Water in Ontario* recommends the following upper limit for chlorine measured in the distribution system for systems that provide secondary disinfection through chlorination:

- free chlorine residual should not exceed 4.0 mg/L

7.8 Microbiological Samples and Chlorine Residual

If the system is currently using chlorination or chloramination and the sample is a distribution system sample taken for microbiological testing, a sample must be taken at the same time and from the same location as the microbiological sample, and tested immediately for chlorine residual. The chlorine residual must be recorded on the microbiological sample submission forms, if specific directions for recording are not provided by the laboratory.

8. OPERATIONAL CHECKS - TURBIDITY TESTING

8.1 What Turbidity is

Turbidity is caused by the presence of suspended particles in the water, and can include silt, organic and inorganic particles, and other microscopic matter. Turbidity is an expression of the light scattering property (or 'cloudiness') of water. The more suspended particles in the water, the "cloudier" it is, and the more light is scattered.

8.2 Why Turbidity is Monitored

Turbidity measurement is important for three key reasons:

1. High turbidity in raw water undergoing chlorination may hinder the chlorination process because pathogens (viruses, bacteria and parasite cysts) may be hidden within the particles suspended in the water and so protect them from the disinfecting effect of chlorine. Turbidity also interferes with the ability of UV to inactivate pathogens.

2. Raw water turbidity measurements are also used to recognize changes in raw water quality over time. A trend of increasing turbidity in raw water may be an indication of deterioration of the raw water source and be used to plan future upgrades to the treatment system.
3. Turbidity is an important indicator of how well a filter is operating. Elevated turbidity levels after a filter may indicate that the filter is not functioning properly. This may mean that the filter may not be removing pathogens at the level credited to the filtration process, and/or that the filter may be producing water that cannot be properly disinfected by the disinfection process that follows filtration.

8.3 Units of Measurement

O. Reg. 170/03 requires that turbidity samples be taken and tested using a turbidity meter that measures in Nephelometric Turbidity Units (NTU) (see section 6-6 of Schedule 6).

8.4 Location and Frequency of Turbidity Testing

8.4.1 Regulatory Samples

O. Reg. 170/03 requires the collection and turbidity testing of:

- raw water samples for <u>most</u> drinking-water systems that use ground water sources and <u>some</u> drinking-water systems that use surface water sources; and
- filter effluent samples or monitoring of filter effluent turbidity using continuous turbidity for surface water systems that are required to provide and are providing filtration. (Non-residential systems that provide ultra-violet (UV) disinfection are not required to conduct turbidity testing provided certain conditions are met (see sections 8-4 of Schedule 8 and section 9-4 of Schedule 9).

In all cases, turbidity samples must be collected and tested from the location(s) or point(s) and at a frequency required by the regulation for the particular system. Requirements in O. Reg. 170/03 and the *Procedure for Disinfection of Drinking Water in Ontario* about the location and frequency of turbidity sampling vary depending upon the system category, the type of filtration process used, and the raw water source. It is the responsibility of the certified operator to provide the supervised person with detailed instructions regarding sampling locations,

schedules and methods where the supervised person is employed to collect samples and perform the turbidity tests.

8.4.2 Turbidity Sampling - Raw Water Samples

Under O. Reg. 170, most systems which are supplied by a **ground water source** are required to take raw water grab samples and test them for turbidity. The regulation requires that these samples be taken from a location that is before the raw water enters the treatment system, and from each well that supplies the system (see section 7-3 of Schedule 7 and section 8-4 of Schedule 8). No raw water turbidity sampling is required for systems under Schedule 9 (small non-residential systems, and non-municipal seasonal residential systems.) In the case of municipal residential systems, Schedule 7 requires raw water sampling and testing for a system that is supplied by a surface water source (including GUDI) if the system does not provide filtration. See the Glossary for the definition of GUDI systems.

8.4.3 Turbidity Sampling - Filter Effluent Samples

In accordance with O. Reg. 170/03 and the *Procedure for Disinfection of Drinking Water in Ontario (Disinfection Procedure)*, filter effluent turbidity must be monitored using continuous turbidity analyzers in all municipal residential systems that obtain water from a raw water supply that is surface water (or GUDI) and that provide filtration.

Systems other than municipal residential systems (that obtain water from a raw water supply that is surface water (or GUDI) and that provide filtration) are required to provide continuous monitoring or daily grab sampling for turbidity, depending on the method of filtration specified in the *Disinfection Procedure*. Non-residential systems that provide ultra-violet (UV) disinfection are not required to conduct turbidity testing provided certain conditions are met (see sections 8-4 of Schedule 8 and section 9-4 of Schedule 9).

8.5 Turbidity Testing using Commercial Portable Turbidimeters

Under O. Reg. 170/03, the only acceptable methods of turbidity testing are methods that measure turbidity in Nephelometric Turbidity Units (NTUs) and allow for immediate reading of the test result. Such testing may be conducted using commercial portable turbidity meters or continuous turbidity analyzers.

Note: Supervised persons may not interpret or respond to the results provided by continuous analyzers, and for this reason, this method is not further discussed in this manual.

8.5.1 Analytical Principles of Nephelometry

The accepted way of measuring turbidity is by using a turbidity meter (also called a turbidimeter) that uses the nephelometric method.

The nephelometric method is actually an indirect measure of the amount of turbidity, and measures the intensity of the light that is scatted by the turbidity (suspended particles) in the water. The higher the intensity of the scattered light, the higher the turbidity (suspended particles) there is in the water sample.

The turbidimeter compares the intensity of light scattered by the particles suspended in the water sample under defined conditions, with the intensity of light scattered by a standard reference suspension (a formazin polymer suspension) under the same conditions.

8.5.2 How to Conduct Tests

In most cases the regulation requires that turbidity be measured using continuous analyzers. However, if the regulation allows discrete (grab) sampling, turbidity must be measured in a sample immediately after sample collection in order to obtain accurate results. The turbidity of a sample can change after the sample is collected and shaking the sample will not re-create the original turbidity.

Instructions for the use of commercial portable turbidimeters vary from manufacturer to manufacturer. For this reason, only general procedural information is provided below. ***The supervised person must follow and have available all manufacturer's instructions and contact information when sampling.***

Common Procedural Practices:

- Calibrate the turbidimeter according to the manufacturer's operating instructions.
- Prepare and measure standards on the turbidimeter that cover the range of samples to be tested. At least one standard should be run in each range used. Based on determination of a standard, make certain the instrument is stable in all ranges.
- When taking a reading, place the instrument on a level, stationary surface. It should not be held in hand.

- When sampling from a tap in a distribution system or treatment plant, allow the water to run for at least five minutes before sampling
- Mix the sample to thoroughly disperse the solids.
- Wait until air bubbles disappear, and then pour the sample into the turbidimeter tube.
- Measure samples immediately to prevent temperature changes and settling
- To measure turbidities of less than 40 NTU, shake the sample thoroughly to disperse the solids. Wait until the air bubbles disappear, and then pour the sample into a turbidimeter tube. Read the turbidity directly from the calibration curve.
- To measure turbidities of more than 40 NTU, dilute the sample with sufficient equal volumes of turbidity-free water to achieve a 30-40 NTU. Calculate turbidity of the original sample from the turbidity of the diluted sample with the dilution factor. Read the turbidity directly from the instrument scale or from the appropriate calibration curve.

8.5.3 General Hints and Cautions

The following tips should be followed in order to ensure that test results are accurate:

Cleanliness of Sample Cells:

- Wearing a pair of latex gloves when sampling. Using laboratory wipes to dry the cells will help keep the optical surface clean and scratch-free.
- Smudges, scratches, air bubbles, fingerprints or fog from cold water on the sample cell's surface can block the light passing through, which may affect the accuracy of the reading - always use clean sample cells in good condition
- Never pour liquid directly into the sample well of the instrument - always use a cuvette. The instrument will only accurately measure the turbidity of a sample when a cuvette with a black cap is used. The black cap serves as both seal and light shield.
- Cap the sample cell to prevent spilling the sample into the instrument
- Avoid settling of sample prior to measurement

8.5.4 Calibration

The equipment should be calibrated according to the manufacturer's instructions.

8.5.5 Standardization

Secondary turbidity standards are suspensions of various materials formulated to match the primary formazin solutions. These secondary standards are generally used because of their convenience and the instability of dilute formazin primary solutions.

Examples of these secondary standards include “standards” that are supplied by the turbidimeter manufacturer with the instrument. Periodic checks of these secondary standards against the primary formazin standard are a must and will provide assurance of measurement accuracy.

8.5.6 Equipment Cleaning & Maintenance

- Always close the sample compartment lid during measurement and storage
- Do not leave a sample cell in the cell compartment for an extended period of time

8.6 Notification of Turbidity Test Results

One of the requirements under sections 7-5, 8-5, and 9-5 of Schedules 7, 8 and 9 of O. Reg. 170/03 that allow a person who is not a certified operator, trained person or water quality analyst to conduct operational tests is that the person must immediately advise a certified operator of all test results. Note that the regulation specifically states all results must be relayed to the certified operator immediately. **All effort must be made to ensure that the supervised person has a direct means to reach the certified operator at all times when he or she is conducting tests on behalf of the certified operator**..

8.7 Adverse Turbidity Results

Immediate notification of results, as described above is particularly critical in the event of adverse results identified in the regulation.

Under section 16-3 Schedule 6 of O. Reg. 170/03, the following is prescribed as an adverse turbidity results for systems that are required to provide filtration (surface water and GUDI):

- a grab sample or two continuous monitoring samples taken 15 minutes apart indicating that turbidity exceeds 1.0 NTU, if a report has not already been made within the previous 24 hours

The SDWA and O. Reg. 170/03 require that the above adverse results be immediately reported to the MOE-Spills Action Centre and MOH. See section 14 - Details on Reporting of Adverse Water Quality Results.

8.7.1 Other Regulatory Requirements & Plant Treatment Targets

The *Procedure for Disinfection of Drinking Water in Ontario* sets further requirements regarding turbidity for various filter types so that water treatment plants receive "credits" for the ability to remove pathogens. For example, certain filtration systems must meet the performance criterion of less than or equal to 1.0 NTU for each filter in 95% of the turbidity measurements that the plant takes every month. This means that most plants will set their operating "targets" to well below that of the adverse quality limit of 1.0 NTU which was described above.

Note: The turbidity concentrations described in the above section describe maximum regulatory requirements. When training the supervised person, the certified operator should be sure to differentiate between these regulatory limits and operational targets that the drinking-water system may have set.

8.7.2 Recommended Maximum Turbidity

The *Procedure for Disinfection of Drinking Water in Ontario* recognizes that turbidity may occur downstream of a treatment system as a result of oxidation (rusting) of mineral particles in the water or other chemical reactions. Despite this, the *Disinfection Procedure* recommends that that turbidity levels be maintained at less than 5.0 NTU for aesthetic reasons.

9. HEALTH AND SAFETY

The supervised person should be provided appropriate health and safety training regarding chemical and physical hazards (e.g. trips, falls) found in a drinking-water system environment, including all applicable health and safety regulatory requirements.

9.1 Chlorine Residual Reagents

For health and safety information about chlorine residual testing reagents, follow the manufacturer's health and safety instructions and all other applicable legislation.

9.2 Disposal of Chemicals and Spoiled Samples

The supervised person is advised to consult with the certified operator regarding proper disposal of any expired testing chemicals or spoiled samples.

10. OTHER REGULATORY SAMPLING & TESTING: MICROBIOLOGICAL AND CHEMICAL PARAMETERS

In addition to conducting the operational checks that are allowed by O. Reg. 170/03, a supervised person may be asked to collect microbiological or chemical samples. Anyone may collect or transport microbiological or chemical samples that are required under Schedules 10-15, as long as the samples are taken and handled in accordance with the directions of the licensed laboratory that will be conducting the testing (see section 6-8 of Schedule 6 of O. Reg. 170/03). O. Reg. 248/03 (*Drinking Water Testing Services*) requires licensed laboratories to provide this information to drinking-water system owners and operators.

Where a supervised person is employed to collect and ship microbiological or chemical samples, the supervising certified operator must ensure that the supervised person is provided and follows the direction of the laboratory regarding sample collection, handling and transportation as required by O. Reg. 170/03.

For all regulatory microbiological and chemical sampling, O. Reg. 170/03 requires that the instructions provided by the licensed laboratory must be followed.

Where the instructions from the licensed laboratory are inconsistent with the general guidance in this manual, the directions of the laboratory must be followed to ensure accurate test results.

10.1 Where to Collect Microbiological and Chemical Samples

O. Reg. 170/03 requires that *for the systems covered in this manual* microbiological samples be taken as raw or distribution samples, depending on the system category. (Large municipal residential systems must also take microbiological treated water samples.)

Chemical samples are to be taken as distribution samples, with some exceptions that are described in section 10.1.2.

10.1.1 Regulatory Raw Water Samples

O. Reg. 170/03 requires that systems supplied by a ground water source including GUDI sources, take raw water samples for microbiological testing. The regulation requires that these samples be taken from a location that is before the raw water enters the treatment system, and from each well that supplies the system (See sections 10-4 of Schedule 10, section 11-3 of Schedule 11, and section 12-4 of Schedule 12).

10.1.2 Regulatory Distribution Samples

O. Reg. 170/03 requires that "distribution samples" be taken “from a point significantly beyond the point at which the drinking water enters the distribution system”. (See subsection 1(1) of O. Reg. 170/03 for the definition of distribution samples). There are two important exceptions to this: chemical samples which must be taken for trihalomethanes (THMs) and lead. Trihalomethanes are by-products created when chlorine-based disinfectants react with organic materials in the water. Systems that must sample for THMs are required to do so at a place in the distribution system that is likely to have an elevated potential for the formation of THMs. Systems which must sample for lead must do so from a point in the distribution system or plumbing that is likely to have an elevated concentration of lead.

Distribution samples must be representative of the whole system and taken from locations that are typical for the system. They can be taken from distribution lines, but they also can be taken from plumbing lines or fixtures where these locations are typical of the system. Some system owners make arrangements with residents so that samples may be taken from consumer's taps. Some municipalities have dedicated outdoor sampling stations.

10.2 Microbiological Sampling

As there are many different kinds of bacteria in water, it would be impractical if not impossible to test for all of them. Instead, microbiological parameters involve the analysis for certain indicator bacteria such as *E. coli*, total coliforms and heterotrophic bacteria.

Under O. Reg.170/03, the sampling locations, frequency and microbiological parameters required to be sampled, vary depending on the system category, the raw water source used by the system, and the type of treatment provided by the system. In all cases, microbiological samples must be collected from the location(s) or point(s) and at a frequency required by the regulation for the particular system.

It is the responsibility of the person in charge of the operation of the system to ensure that appropriate samples are collected and sent for laboratory testing in accordance with the regulatory requirements applicable to the particular system. Where a supervised person is employed to collect and ship microbiological samples, the supervising certified operator must ensure that the supervised person is provided with detailed instructions regarding the sampling locations and schedule specific to the system. The certified operator must also ensure that the supervised person follow the instructions of the licensed laboratory when collecting, handling and transporting the samples.

10.2.1 Microbiological Sample Collection Procedures

If the sample collection and transportation directions from the laboratory differ from the guidance below, always follow the directions of the laboratory.

When collecting microbiological samples, remember to:

- Always ensure a clear pathway from the source to the sample collection point by removing aerators, tap screens, hoses, filters, etc, from any tap used during sample collection.
- Always allow the water to run for at least two minutes before collecting drinking water samples.
- Always use the sampling bottles provided by the licensed laboratory. These will be sterile bacteriological sampling bottles containing the preservative sodium thiosulphate. If these bottles have tamper-proof seals and the seal has been broken, consider the bottle contaminated and request that the laboratory provide a new bottle.
    - The purpose of the preservative in the sampling bottles is to prevent the collected water quality from degrading. Degradation means that the sample will no longer accurately reflect the quality of the water in the system. Do not touch or handle the preservative. Do not rinse the containers, as this will remove some or all of the preservative, and ruin the sample. Do not touch the inside of the sampling container or cap. The inside of the cap and container should not come into contact with anything other than the atmosphere and the collected sample. Cap the bottle immediately after sample collection. Ask the laboratory for further instructions if necessary.
- Always label the sample and ensure the laboratory Chain of Custody form is completed. Always follow the laboratory's instructions concerning sample packaging, storage and transportation. Otherwise, the laboratory may refuse to analyze the samples.

- As "false positive" results can occur due to improper handling of sample containers or the use of improper containers, it is critical that care be taken in the collection and handling of these samples so as not to undermine consumer confidence in the drinking-water supply.

10.3 Chemical Sampling

Chemical sampling required under O. Reg. 170/03 is described under Schedules 13 and 15, depending on the category of the system. Also, Certificates of Approval or Orders issued by the ministry may require additional chemical parameters to be monitored.

Under O. Reg.170/03, the sampling locations and frequency of chemical sampling vary according to the system category. Where a supervised person is employed to collect and ship chemical samples, the supervising certified operator must ensure that the supervised person is provided with detailed instructions regarding the required sampling locations and schedule specific to the system. The certified operator must also ensure that the supervised person follow the instructions of the licensed laboratory when collecting, handling and transporting the samples.

10.3.1 Sampling for Organic Parameters

In general, organic parameters are compounds containing carbon. Typical organic compounds include pesticides, petroleum products, polychlorinated biphenyls (PCBs), phenols, chlorinated or non-chlorinated solvents, etc. Organic compounds can be liquid, solid or gaseous. Some dissolve or mix with water and others do not.

If the sample collection and transportation directions from the laboratory differ from the guidance below, always follow the directions of the laboratory.

Sample Collection Procedures - Organics

- Take considerable care when collecting these samples as contamination may occur from the outside of the sample containers and other materials such as gloves. (The unstable nature of many organic compounds requires strict adherence to sampling protocols, including the use of proper sample containers and preservatives, if recommended.)
- Use sampling bottles provided by the laboratory. For most organic compounds a glass container is necessary. Some organic compounds are light-sensitive and require brown glass containers or storage away from light. The laboratory will provide this direction. Sample volume is a major

consideration when collecting organic samples; in most cases, a relatively large sample size (500 to 1000 mL) is required.

Sample Collection Procedures - Volatile Organic Compounds (VOCs)

- For samples that require analysis for volatile components (i.e., benzene, toluene, etc.), collect the samples in such a manner that no headspace (air pocket) is left in the bottle.
- To eliminate headspace, fill the container slowly to overflowing, avoiding any mixing or shaking.
- Place the cap on the bottle while the sample is overflowing, or fill sample slowly until there is a convex meniscus (dome) of water extending higher than the top of the container. Cap carefully; a small amount of sample may be lost when capped. Once capped, turn the bottle upside down. No air bubble should be present.

10.3.2 Sampling for Inorganic Parameters

For the testing of inorganic parameters, laboratories generally require one or more samples for what they term general chemistry testing and a separate sample for metals testing because a preservative is required to stabilize the metals in the sample. General chemistry tests include nutrients (nitrate, nitrite) and ions such as fluoride or sodium. For the most part, these tests are performed on water samples to assess the overall quality of the water. A metal analysis can include commonly known elements such as iron, copper, lead, mercury and manganese.

If the sample collection and transportation directions from the laboratory differ from the guidance below, follow the directions of the laboratory.

Sample Collection Procedures - Inorganics

- Use the sampling bottles provided by the laboratory. If the bottle contains a preservative, do not touch or handle the preservative. Do not rinse the containers, as this will remove some or all of the preservative, reducing the accuracy of the test results. Do not allow the sample bottle to overflow or the preservative will be diluted. Ask the laboratory for further instructions if necessary.
- In some cases, such as when strong acid is used to preserve the sample, the laboratory may provide direction to add the preservative after taking the sample. It is very important that these directions be followed if provided.
- All sampling bottles should be filled to the shoulder or to the mark on the label or bottle.

- In general, inorganic compounds are sampled in plastic containers, although glass containers may be used for some tests such as mercury.

11. LABELLING SAMPLES

Accurate and complete labelling of microbiological and chemical samples ensures that the sample's identity is maintained and traceable when they are sent to the laboratory for analysis. This is vital for sample tracking and data interpretation.

All sample containers should be labelled prior to taking the sample to prevent confusion. A permanent marker or pen (non-water soluble) should be used and the label must be water resistant

The following information type of information must be recorded on the sample label and on an accompanying laboratory sample submission/Chain of Custody Form as directed by the licensed laboratory:

1. Marking to indicate that the sample is a *regulated drinking water sample*;
2. Identification of applicable regulations (e.g. O. Reg. 170/03);
3. Sample type: raw, treated or distribution;
4. A unique sample identifier;
5. The legal name of the drinking-water system (available in the ministry's Drinking Water Information System (DWIS));
6. The drinking-water system number (also known as the waterworks number);
7. The date and time of sample collection;
8. The street address, if the sample is a distribution sample;
9. Preservative(s) used;
10. Pertinent field measurements (e.g. chlorine residual, turbidity, pH); and any other sampling observations made;
11. The full first and last name of the sampler.

Much of this information can be put on the labels/tags in advance of sampling, either by the laboratory or the sampler. Pre-printed labels with the drinking-water system name, number, sample type, etc, are convenient, provide the necessary information for the lab analyst and help prevent mix-ups in labelling. In some cases, sample tags used by laboratories have space to write the test requests. In all cases, separate

sample information sheets must be submitted to the laboratory with the samples (see section 12 – Chain of Custody Forms, of this manual).

Correctly recording the sample identification is especially critical for parameters which have health-based standards (O. Reg. 169/03); samples must be traceable for legal purposes. Correct sample identification is also the key to ensuring accurate reporting of all water quality data.

12. CHAIN OF CUSTODY FORMS

As discussed above, proper sample labelling is crucial to maintaining the identity of a sample when it is sent to a laboratory for analysis; in addition, a procedure is required to ensure samples can be traced from the time of collection through to analysis. These steps are referred to as a chain-of-custody, and are used to ensure the integrity of the sample and resulting data.

When samples are collected, a laboratory Chain of Custody Form provides an accurate written record that can be used to trace the possession, transfer and custody of a sample from the time of its collection through to its analysis and reporting.

Each person involved in the chain of possession must sign the custody form when a sample or set of samples is received or relinquished.

13. FINAL IMPORTANT SAMPLING & TESTING COMMENTS

The following comments apply to all sampling conducted for a drinking-water system, whether operational, microbiological or chemical:

- **The accuracy of the analytical result is ONLY as good as the care that was taken in collecting the sample.**
- **Collection of a bad sample or a bad laboratory result is WORSE than no result.**
- **Remember: the test results are only as good as the sample.**

14. DETAILS ON REPORTING OF ADVERSE WATER QUALITY RESULTS

14.1 Roles and Responsibilities

Throughout this manual, and especially in its Section 4, mention has been made several times regarding the regulatory obligation to report adverse results. It is hoped that the preceding sections have provided the supervised person an understanding of how important monitoring is. It is just as important for the supervised person to know what the roles and responsibilities of the operating authority or drinking-water system owner are, and what procedures to follow in the event of an adverse result of a drinking water test.

The certified operator conducting the training of the supervised person is reminded of the operating authority's or drinking-water system owner's duty to report adverse test results under section 18 of *Safe Drinking Water Act, 2002.*

The certified operator should clarify to the supervised person what his/her role and responsibilities are in the context of the operating authority's or drinking-water system owner's regulatory obligations. The supervised person should be provided clear instructions, and contacts to ensure that the drinking-water system owner and operating authority's obligations are fulfilled.

14.2 Notification Requirements in the Case of Adverse Test Results

An adverse test result is a prescribed adverse test result listed in section 16-3 of Schedule 16 of O. Reg. 170/03. It can also be test result that exceeds the standards listed in the Ontario Drinking-Water Quality Standards Regulation (O. Reg. 169/03) made under the *Safe Drinking Water Act, 2002*.

As soon as the owner / operating authority becomes aware of an adverse test result either from a test result of a sample taken on-site or from the licensed laboratory or if it has been observed that the drinking-water system is directing water to users that has not been disinfected in accordance with the ministry's *Procedure for the Disinfection of Drinking Water in Ontario*, it is required that the local Medical Officer of Health AND the ministry's Spills Action Centre (SAC) be immediately contacted.

14.3 What to do if an adverse test result is observed

The owner/operating authority of the system should ensure *ahead of time* that contact information for the Ministry's Spills Action Centre and the local Medical Officer of Health is easily accessible.

1. Immediately report the adverse test result or other problem to all of:

- The **Ministry of the Environment's Spills Action Centre (1-800-268-6060)** (the Spills Action Centre is open 24 hours/day and 365 days/year) ***and***
- The local Medical Officer of Health at the local Public Health Unit, by speaking with someone in person or on the telephone. Contact information for the local Public Health Units can be found in the blue pages or at: http://www.health.gov.on.ca/english/public/contact/phu/phuloc_mn.html; ***and***
- The operator of each *designated facility* served by the drinking-water system, by speaking with someone in person or on the telephone.

2. Deliver written notice, within 24 hours of giving verbal notice, to:

- The MOE's Spills Action Centre (by fax at 1-800-268-6061), ***and***
- The local Medical Officer of Health (by fax or in person), ***and***
- The operator of a designated facility (by fax or in person), ***and***
- The interested authority for the *designated facility* (by fax).

3. It is the owner / operating authority's responsibility to ensure that the following steps are taken:

- To take corrective action if an adverse result or other problem is noted;
- Deliver follow-up notice of corrective action taken.

Remember: The supervised person's responsibilities do not extend to operation of a drinking-water system. Only certified operators or trained persons have the regulatory authority to operate a drinking water system which includes making adjustments to treatment and chemical processes.

15. RECORD-KEEPING REQUIREMENTS

15.1 Regulatory Requirements

Accurate, reliable records are important to document the effectiveness of the water treatment plant operation and are required by MOE regulations.

O. Reg. 170/03 (section 6-10 of Schedule 6) requires that the owner of a drinking-water system and the operating authority for the system ensure that, for every sample required by the Regulation (or an approval or order), a record is made of the following information:

1. The date and time the sample was taken, the location where the sample was taken and the name of the person who took the sample.
2. If the sample is taken under section 7 or Schedule 7, 8 or 9 (maintenance and operational checks) of O. Reg. 170/03, the date and time the sample was tested, the name of the person who conducted the test, and the results of the test.

The Regulation also requires that the records or reports for all tests required under O. Reg. 170/03 be kept for 2 to 15 years (depending on the parameters in question) (section 13). All reports and records of test results must be made available for inspection by any member of the public or the MOE during the prescribed timeframe (section 12). See O. Reg. 170/03 for more details.

When collecting samples, it is very important to record the date and time the sample was taken. For example, the recording of the time when the sample was taken is very critical when microbiological samples are collected because holding times differ significantly between parameters. The location where the sample was taken and the name of the person who took the samples must also be recorded, as required by O. Reg. 170/03.

16. FINDING MORE INFORMATION

See the ministry's document "Practices for the Collection and Handling of Drinking Water Samples", which is available on the ministry's website at www.ene.gov.on.ca.

To be clear about specific legal requirements, refer to the text of the Drinking-Water Systems Regulation (O.Reg.170/03) and the *Safe Drinking Water Act*, 2002. These may be accessed via the government's e-laws web-site at www.e-laws.gov.on.ca, or the ministry's web site at www.ene.gov.on.ca under the section entitled "Water", or by calling the ministry's Public Information Centre at 1-800-565-4923.

17. GLOSSARY

AMPEROMETRIC

A method of measurement that records electric current flowing or generated, rather than recording voltage. Amperometric titration is a means of measuring concentrations of certain substances in water.

ANALYZER

A device that conducts periodic or continuous measurement of some factor such as chlorine, fluoride or turbidity. Analyzers operate by any of several methods including photocells, conductivity or complex instrumentation.

CALIBRATION

A procedure that checks or adjusts an instrument's accuracy by comparison with a standard or reference.

COLOURIMETRIC MEASUREMENT

A means of measuring unknown chemical concentrations in water by measuring a sample's colour intensity. The specific colour of the sample developed by addition of chemical reagents, is measured with a photoelectric colorimeter or is compared with "colour standards" using, or corresponding with, know nconcentrations of the chemical.

COMBINED CHLORINE

That portion of the total chlorine present in water that has reacted with ammonia and certain organic nitrogen compounds and has formed one or more different types of chloramines, including organic chloramines.

FREE CHLORINE

That portion of the total available residual chlorine composed of dissolved chlorine gas, hypochlorous acid, and/or hypochlorite ion, remaining in water after chlorination. This does not include chlorine that has combined with ammonia, nitrogen, or other compounds.

GRAB SAMPLE

A discrete, single sample of water collected at a particular time and place, and that represents the composition of the water only at that time and place.

GUDI

An acronym that stands for “ground water under the direct influence of surface water”. It is typically used to describe wells are not secure from surface water impacts. O. Reg. 170/03 deems a drinking-water system that obtains its raw water from a GUDI source to be the same as drinking-water system that obtains water from a surface water source for purposes of the regulation. (See section 2 of O. Reg. 170/03).

MENISCUS

The curved surface of a column of liquid (water, oil, mercury) in a small tube. When the liquid wets the sides of the container (as with water), the curve forms a valley. When the confining sides are not wetted (as with mercury), the curve forms a hill or upward bulge.

ORGANICS

Substances that come form animal or plant sources, including petroleum, natural gas and coal, and their industrial derivatives. Organic substances always contain carbon. Inorganic materials are chemical substances of mineral origin.

pH

pH indicates the acidity of a water, on a scale of 0 to 14. Neutral water has a pH of 7. Natural waters usually have a pH of between 5 and 10.

PRESERVATIVE

A chemical added to a water sample to keep it stable and prevent compounds in it from changing to other forms, or to prevent micro-organism densities from changing prior to analysis.

RAW WATER

(1) Water in its natural state, prior to any treatment.
(2) Usually the water entering the first treatment process of a water treatment plant.

REAGENT

A pure chemical substance that is used to make new products or is used in chemical tests to measure, detect or examine other substances.

RECORDER

A device that creates a permanent record, on a paper chart or magnetic tape, of the changes in a measure variable.

RESIDUAL CHLORINE

The amount of free and/or combined chlorine remaining after a given contact time under specified conditions.

SURFACE WATER

All water open to the atmosphere (rivers, lakes, reservoirs, streams, impoundments, seas, estuaries) and all springs, wells or other collectors that are directly influenced by surface water.

TITRATE

To titrate a sample, a chemical solution of known strength is added drop by drop until a certain colour change, precipitate or pH change in the sample is observed (end point). Titration is the process of adding the chemical reagent in increments until completion of the reaction, as signalled by the end point.

TOTAL CHLORINE

The total concentration of chlorine including both free chlorine and combined chlorine) present in a water sample. It is the value of residual chlorine without the reference to the contact time after which the measurement is made (see Residual Chlorine)

TREATED WATER

Water that has passed through a water treatment plant; all the treatment processes are completed. This water is ready to be delivered to consumers. Also called Finished Water.

TRIHALOMETHANES (THMs)

Derivatives of methane, CH_4, in which three halogen atoms (chlorine or bromine) are substituted for three of the hydrogen atoms. Often formed during chlorination by reactions with natural organic materials in the water. The resulting compounds (THMs) are suspected of causing cancer.

TURBIDIMETER

An instrument for measuring the turbidity of liquids by passing light through them and determining how much light is reflected by the particles suspended in the liquid, and comparing it to the amount of light reflected by a standardized suspension of particles. The normal measuring range is 0 to 100 and is expressed as Nephelometric Turbidity Units (NTUs).

TURBIDITY

The cloudy appearance of water caused by the presence of suspended and colloidal matter. A turbidity measurement is used to indicate the clarity of water. Turbidity is an optical property of the water based on the amount of light reflected by suspended particles. Turbidity can not be directly equated to the mass concentration of suspended solids (normally expressed in mg/L) because white particles reflect more light than dark-coloured particles, and many small particles will reflect more light than an equivalent large particle.

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APPENDIX 1: SYSTEMS THAT PRACTICE CHLORAMINATION

A-1 Chloramination and the Measurement of Combined Chlorine Residual

A chemical disinfection process that uses a form of chlorine called “chloramines” is called chloramination.

Chloramines form when chlorine reacts (or combines) with ammonia, ammonium ions, and nitrogen-containing organic substances called amines. The chloramines constitute a “combined chlorine residual”, which is the type of chlorine that must be monitored when chloraminating.

The substances mentioned above that chlorine can combine with in order to form chloramines may be naturally-occurring and found in raw water. However, during chloramination, chlorine and ammonia are added at a water treatment plant in order to create chloramines, with the ammonia addition usually downstream of the application of chlorine.

Because chloramines have relatively low effectiveness in pathogen inactivation but persist in water much longer than free chlorine, chloramination is commonly used to maintain a chlorine residual in the water distribution system (for secondary disinfection). In Ontario, chloramination is often used as a form of secondary disinfection in large municipal residential systems, and by a few small municipal residential systems. Very few other categories of systems use chloramination for secondary disinfection purposes; chloramination is very rarely used by any category of system for primary disinfection.

A-2 Chloramination and the Calculation of Combined Residual using Free and Total Chlorine Residual Measurements

Chloramination involves achieving a fine chemical balance between the amount of chlorine and ammonia that are added to form chloramines. Any excess chlorine that does not combine with the ammonia to form the chloramines (or combined residual) is usually in the form of free chlorine.

When free chlorine residual AND combined chlorine are added, the sum of the two is called the total chlorine residual.

Free chlorine residual + combined chlorine residual = Total chlorine residual

Portable and some on-line chlorine residual monitoring equipment commonly used are capable of measuring either free chlorine residual or total chlorine residual but NOT combined chlorine residual. When using a portable (or hand-held analyzer), in order to determine combined chlorine residual, separate tests for total chlorine residual and free chlorine residual must be made. By reorganizing the formula above, one can see that free chlorine residual can be subtracted from the total chlorine residual in order to obtain the combined chlorine residual concentration.

Total chlorine residual - free chlorine residual = combined chlorine residual

As stated before, chloramination involves achieving a fine chemical balance to ensure that the right amount of chlorine and ammonia are added to form chloramines without resulting in any excess chemicals. Where ammonia addition is properly adjusted in drinking-water systems which use only chloramination for secondary disinfection, no free chlorine residual would show in distribution system tests. Therefore, the *Procedure for Disinfection of Drinking Water in Ontario states:* "for such systems the measurement of total chlorine residual only would be adequate to represent the value of a combined chlorine residual". If a system chooses to use total chlorine residual as a representative measure of combined chlorine, free chlorine concentration checks must be conducted with enough frequency to ensure that free chlorine exists in negligible concentrations.

A-3 DPD Method of Conducting Chlorine Residual Testing (for Systems that Provide Chloramination):

Refer to section 7.5 of the manual for other general information regarding the DPD method for chlorine residual analysis. The following replaces the corresponding information for "Free Chlorine Determination Procedure (for systems that provide chlorination)" under section 7.5.3.

Total Chlorine Determination Procedure (for systems that practice chloramination):

1. Rinse two identical viewing tubes with chlorine-free distilled water or treated water without reagent. Check the instructions of the manufacturer about the water that is to be used for rinsing & cleaning.
2. Add entire contents of pre-packaged total chlorine reagent to the sample viewing tube. Cap and swirl to mix (Occasionally, swirling alone does not

produce good precision in data. To solve this problem, shake the sample vigorously for 15 seconds, then swirl to remove air bubbles. The powder does not have to dissolve completely to obtain a correct reading.) This is the sample viewing tube. The total chlorine reagent takes usually takes around minutes to react. In the meantime, conduct steps 3 and 4.

3. Fill the second viewing tube (the control viewing tube) to the graduation mark recommended by the manufacturer with water to be tested, and place it in the cell compartment.
4. Press the “zero” key and remove the control viewing tube after the instrument has confirmed that the instrument has been zeroed.
5. After the time recommended by the manufacturer for the total chlorine reagent to react has elapsed, place the sample viewing tube in the cell compartment
6. Press the “read” key. The instrument will automatically conduct the comparative analysis and will display the total chlorine residual result.
7. For instruments which rely on use of a manual colour wheel, hold the comparator to a light source and compare the sample viewing tube to the comparator standard colour scale. When a colour match is achieved, record the total chlorine residual in mg/L. The total chlorine residual must be read within the time recommended by the manufacturer (usually one minute).

A-4 Adverse Chlorine Residual Results vs. Chlorine Residual Targets (for Systems that Provide Chloramination)

Immediate notification of operational test results is particularly critical in the event of adverse chlorine residual results identified in the regulation. The obligations of an operating authority or drinking-water system owner to report adverse results were described under sections 2 and 14 of the manual.

A-4.1 Minimum Combined Residual (Primary Disinfection)

Chloramination is very rarely used for primary disinfection purposes: because chloramines are a weak disinfectant, the contact time that would be required to provide proper disinfection would be extremely long.

O. Reg. 170/03 requires that: "an observation which indicates that a drinking-water system is directing water that has not been properly disinfected in accordance with the ministry’s *Procedure for Disinfection of Drinking Water in Ontario* to users of the system must be reported". (See section 16-4 of Schedule 16, O. Reg. 170/03).

The *Procedure for Disinfection of Drinking Water in Ontario* (the *Disinfection Procedure*) requires a drinking-water system owner to determine the chlorine residual concentration and contact time that will meet the primary disinfection requirements of the *Disinfection Procedure*. This chlorine residual concentration will vary from plant to plant depending on the characteristics of the raw water, the treatment processes and chemicals used. The supervised person should be clearly informed by the certified operator of the chlorine residual that is required to achieve primary disinfection in the plant, and the location within the process where contact time has just been completed

A-4.2 Minimum Combined Chlorine Residual (Secondary Disinfection)

The following is prescribed as an adverse result of a drinking water test under section 16-3 of Schedule 16 for systems which provide chloramination:

- A result indicating the concentration of combined chlorine residual is less than 0.25 mg/L **and** the concentration of free chlorine residual is less than 0.05 mg/L in a distribution sample that is a grab sample, if the system provides chloramination and an adverse report in respect of combined chlorine residual has not been made in the previous 24 hours.

The SDWA and O. Reg. 170/03 require that the above adverse results be immediately reported to the MOE-Spills Action Centre and MOH. See section 14 - Details on Reporting of Adverse Water Quality Results.

A-4.3 Maximum Combined Chlorine Residual (Maximum Concentration of Chloramines)

The *Procedure for Disinfection of Drinking Water in Ontario* sets the following upper limit for combined chlorine residual measured ***in the distribution system***:

- combined chlorine residual at any time and at any location within the distribution system should not exceed 3.0 mg/L

Similarly, Schedule 2 of O. Reg. 169/03 – Ontario Drinking Water Quality Standards prescribes a *Maximum Acceptable Concentration (MAC) of 3.0 mg/L for chloramines.*

<Section A-4.3 is continued on next page>

Concentration of chloramines and combined chlorine residual are equivalent measures, and a combined chlorine residual test result exceeding 3.0 mg/L is a reportable adverse test result with respect to the concentration of chloramines .

Note: The chlorine residual concentrations above describe minimum and maximum regulatory requirements. When training the supervised person, the certified operator should be sure to differentiate between these regulatory limits and operational targets that the drinking-water system may have set.