

FT 2000. Field Measurement of Residual Chlorine

Use in conjunction with:

- FA 1000 Regulatory Scope and Administrative Procedures for Use of DEP SOPs
- FT 1000 General Field Testing and Measurement
- FS 1000 General Sampling Procedures
- FS 2000 General Aqueous Sampling
- FD 1000 Documentation Procedures
- FC 1000 Cleaning / Decontamination Procedures
- FM 1000 Field Planning and Mobilization

Chlorinating water supplies and polluted waters at treatment facilities is a common practice to destroy or deactivate disease-producing microorganisms. This SOP describes the most commonly used field procedures for measuring the residual chlorine that remains after chlorination.

For reporting limits below 0.2 mg Cl/L, use the titrimetric methods in FT 2020. The methods in FT 2010 or FT 2030 may be used if a lower detection limit and range of calibration can be demonstrated in the sample matrix of interest.

See the applicable referenced methods in FT 2050 if measurements other than total residual chlorine are required. Use this SOP when analyzing drinking water compliance samples for free or total chlorine (section 2.1.2).

FT 2010. DPD COLORIMETRIC METHOD

1. SCOPE AND APPLICABILITY: DEP recommends this method if the testing levels that must be met are between 0.2 to 4.0 mg/L residual chlorine. This method is least affected by the presence of organic matter.

2. EQUIPMENT AND SUPPLIES

2.1. Field Instruments:

2.1.1. Use any of the following photometric instruments for residual chlorine measurements. The instrument must allow calibration using **at least** two standards and a blank, except as noted in 3.2.2 below.

- Spectrophotometer, for use at a wavelength of 515 nm and a light path of 1 cm or longer;
- Filter Photometer, equipped with a filter having maximum transmission in the wavelength range of 490 to 530 nm and providing a light path of 1 cm or longer or
- Colorimeters designed for residual chlorine measurement

2.1.2. Color Comparator: use only for the analysis of free and total chlorine in drinking water samples for compliance monitoring

2.2. Appropriate laboratory glassware such as volumetric flasks and volumetric pipets.

2.3. Sample Cells (cuvettes): Use sample cells or tubes of clear, colorless glass or plastic specifically designed for the test instrument.

2.3.1. Keep cells clean, both inside and out, and discard if scratched or etched.

2.3.2. Never handle cells where the light beam strikes the sample.

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2.3.3. Clean sample cells by thorough washing with laboratory detergent solution (inside and out) followed by multiple rinses with distilled or de-ionized water. Air dry sample cells prior to use or rinse thoroughly with sample before color development and measurement.

2.3.3.1. Sample cells may be rinsed in the field with the detergent step omitted if it is determined that no interference with accurate measurement will occur and that the sample has not left insoluble residue on the surfaces of the cell.

2.3.4. Mask minor imperfections or scratches in the cells with a very thin layer of silicone oil on the outside surfaces. Use silicone oil with the same refractive index of the glass; making sure the cell appear to be nearly dry with little or no visible signs of oil.

2.3.5. Because small differences between cells significantly impact measurement, use optically matched cells or use the same cell for calibration and sample measurement.

2.4. Reagents and Standards:

- DPD reagent powder pillows (from commercial supplier) or
- Phosphate buffer solution and DPD indicator solution (prepared according to SM 4500-Cl-G).
- Chlorine-demand-free water

2.4.1. Primary Standards: Use standard potassium permanganate solutions or chlorine standards prepared in the appropriate concentration range of interest according to method SM 4500-Cl-G. The primary standards should only be prepared by persons or organizations proficient in preparing analytical standards. Do not reuse primary standards.

2.4.2. Secondary Standards: Use secondary standards certified by the manufacturer for a specific instrument model. Use secondary standards only for continuing calibration verifications according to the procedures in section 3.2.6. Verify the values of secondary standards according to the procedure and frequency outlined in section 3.2.5.

2.4.2.1. Care of Secondary Standards: Protect standards from direct sunlight, heat and scratches.

- Store the standards in the upright position. The most convenient way is to keep the standards in the original storage box provided by the manufacturer.
- During transport to and from the field, keep the standards in an air-conditioned vehicle away from the sun. Do not store on the dashboard or in the trunk if a vehicle.
- If the vehicle is not air conditioned, the standards may be placed in a watertight plastic bag and kept cooled in an ice chest.
- When not in use, store the standards in air conditioning or in ambient air not to exceed 90°F.
- Avoid getting fingerprints on the glass vial. Handle the standards only by the cap.
- Before daily use, inspect the secondary standard vials and, if necessary, clean the outside of the standard vials with a dilute solution of detergent, followed by a deionized or distilled water rinse. Wipe dry with lint-free paper or cloth.

2.4.2.2. Discard the standards set when:

- the standard value can no longer be verified (3.2.5);

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- obvious discoloration or fading has occurred,
- residue on the surfaces of the vials cannot be removed,
- scratches are visible on the glass vials; or
- a secondary gel standard has melted or resolidified in a position different from the original.

2.5. Recordkeeping and Documentation Supplies:

- Field notebook or forms (waterproof paper is recommended))
- Indelible pens

3. CALIBRATION AND USE

3.1. Interferences: Sample color and turbidity may interfere in all colorimetric procedures applied to natural and treated waters. Other possible interferences are from: bromine, chlorine dioxide, iodine, permanganate, hydrogen peroxide, and ozone. If interferences are suspected, consult the applicable method for guidance (see FT 2050).

3.2. Calibration

3.2.1. Follow the calibration activities in FT 1000.

3.2.2. Initial Calibration: Use the primary standards (see 2.4.1 above) for initial calibration. An initial calibration must be performed if verification attempts are not successful (see 3.2.4 and 3.2.6 below).

3.2.2.1. Use a minimum of a blank and two standards that bracket the range of the sample measurements.

3.2.2.2. If the instrument cannot be calibrated with a blank and two standards, calibrate with a blank and one standard that bracket the range of the sample measurements.

3.2.2.3. Verify instruments with pre-set or factory calibrations against primary standards per 3.2.3 below.

3.2.2.4. The correlation coefficient of the standard calibration curve must be greater than or equal to 0.995 for all calibrations.

3.2.3. Instruments with Pre-Set or Factory Calibration

3.2.3.1. Instruments with a pre-set calibration do not require an initial calibration if the instrument calibration is verified with primary standards over the range of use (see 3.2.4 and 3.2.6 below for verification procedures).

3.2.3.2. Verify with primary standards before first use and at least annually.

3.2.3.3. Perform an initial calibration (3.2.2 above) when verification attempts are not successful.

3.2.4. Initial Calibration Verification: Immediately after calibrating an instrument, perform an initial calibration verification by reading at least one primary standard as a sample. The value of this standard must be within quantitative calibration bracket established in 3.2.2 above. The instrument reading from this standard must be within 10% of its standard value.

3.2.4.1. Perform initial verifications of color comparators per 3.2.6.4 below.

3.2.5. Determining or Verifying the Values of Secondary Standards:

3.2.5.1. Use only those certified by the manufacturer for a specific instrument. The values of secondary standards may be dependent on the make and model of the

instrument. **Perform all steps of the verification process on the same instrument model that will be used with the secondary standards.**

3.2.5.2. At a minimum, verify the values of secondary standards annually or when

- The standards appear to have been damaged;
- The standards were stored in direct sunlight;
- The meter failed to meet verification requirements with the secondary standards
- **More frequent calibration verifications are required for discharge permit compliance measurements or other regulatory requirements.**

3.2.5.3. Determine or verify the values of secondary standards using the following procedure

- Perform an initial calibration or calibration verification with primary standards.
- Select the primary standard concentrations so that the secondary standard concentrations are bracketed with acceptable primary standards.
- Immediately after verifying the acceptability of the calibration, read each secondary standard as a sample.
- This result must be within the manufacturer's stated tolerance range and +/- 10% of the stated standard value.
- If the +/- 10% criterion is not met, but the result is within the manufacturer's stated tolerance range, assign the reading as the value of the standard.
- If the reading is outside the +/- 10% criterion **and** the manufacturer's stated tolerance range, discard the secondary standard.

3.2.6. Continuing Calibration Verification:

3.2.6.1. Perform a continuing calibration verification using at least one primary or secondary standard. The concentration of the CCV standard should be within the initial calibration bracket established in 3.2.2 above and cannot be a zero or blank standard.

- If sample concentrations are outside the range established by the initial calibration, the range may be extended by selecting a continuing calibration verification standard that will bracket the sample concentrations.
- If sample concentrations exceed the range setting of the instrument (e.g., high or low range), verify at least two standards that bracket the sample in the alternate range setting.

3.2.6.2. Each CCV measurement must be within 10% of the known standard value. For secondary standards, use the known value(s) determined in 3.2.5 above. If any CCV attempt fails to meet the 10% acceptance criterion, establish the cause of the failure and reattempt the CCV before analyzing samples. The instrument must be recalibrated with an initial calibration (see 3.2.2 above) if the CCV acceptance criterion cannot be achieved. Qualify as estimated all sample measurement data obtained since the last acceptable verification.

3.2.6.3. Perform a CCV after the last sample measurement has been taken, but no longer than 24 hours after the previous verification. If historically generated data demonstrate that a specific instrument remains stable for longer periods of time, the time interval between calibration verifications may be increased (see FT 1000 section 2.2.5).

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3.2.6.4. For color comparators, verify comparator accuracy every six months by evaluating the comparator against primary standards with concentration values bracketing sample measurements. If the comparator readings differ from the standard values by more than 10%, qualify all sample measurements made since the last verification as estimated. Plot the comparator readings against the primary standard values. Use the plotted graph as a correction curve to be applied to future analyses of samples with the comparator. Replace comparators if color scales appear faded or discolored.

3.3. Sample Analysis (spectrophotometer or photometer):

3.3.1. Rinse the cuvette with a small amount of sample.

3.3.2. Discard the rinsate, and fill the cuvette with sample.

3.3.2.1. If samples are colored or turbid, compensate for these interferences by "zeroing" the meter with the sample before adding the chemicals for color development.

3.3.3. Add the reagents (DPD, buffer, etc.) to the sample according to the manufacturer's instructions.

3.3.4. Invert the container to mix.

3.3.5. Wait the required time for color development as specified in the referenced method or manufacturer's instructions. Do not exceed the maximum allowable time for color development before reading the sample.

3.3.6. Gently wipe the sides with a lint-free tissue and insert the cuvette into the instrument.

3.3.7. Follow the instrument's instructions for obtaining the sample value (either by direct read-out or by using a plot of the calibration curve).

3.3.8. After recording the sample reading, remove the cuvette, discard the sample and rinse the cuvette 3 – 5 times with de-ionized or distilled water.

3.3.9. Repeat steps 3.3.1 through 3.3.8 until all samples have been tested.

3.3.10. If the concentration of the samples exceeds the range setting of the instrument (e.g., high or low), change the range setting, and read the samples again. See 3.2.6.1 concerning calibration verification in a different range from the original initial calibration.

3.4. Color Wheel Comparator: Follow the manufacturer's instructions for obtaining the sample value from a color wheel when used for drinking water sample analysis.

4. PREVENTIVE MAINTENANCE: Refer to FT 1000, section 3.

5. DOCUMENTATION:

5.1. Standard and Reagent Documentation: Document information about standards and reagents used for calibrations, verifications, and sample measurements.

6.1.1. Note the date of receipt, the expiration date and the date of first use for all standards and reagents.

5.1.1.1. Document acceptable verification of any standard used after its expiration date.

5.1.2. Record the concentration or other value for the standard in the appropriate measurement units.

5.1.2.1. Note vendor catalog number and description for preformulated solutions as well as for neat liquids and powdered standards.

5.1.2.2. Retain vendor assay specifications for standards as part of the calibration record.

5.1.3. Record the grade of standard or reagent used.

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5.1.4. When formulated in-house, document all calculations used to formulate calibration standards.

5.1.4.1. Record the date of preparation for all in-house formulations.

5.1.5. Describe or cite the procedure(s) used to prepare any standards in-house (DEP SOP or internal SOP).

5.2. Field Instrument Calibration Documentation: Document acceptable calibration and calibration verification for each instrument unit and field test or analysis, linking this record with affected sample measurements.

5.2.1. Retain vendor certifications of all factory-calibrated instrumentation.

5.2.2. Designate the identity of specific instrumentation in the documentation with a unique description or code for each instrument unit used.

5.2.2.1. Record manufacturer name, model number, and identifying number such as a serial number for each instrument unit.

5.2.3. Record the time and date of all initial calibrations and all calibration verifications.

5.2.4. Record the instrument reading (value in appropriate measurement units) of all calibration verifications.

5.2.5. Record the name of the analyst(s) performing the calibration.

5.2.6. Document the specific standards used to calibrate or verify the instrument or field test with the following information:

- Type of standard or standard name (e.g., potassium permanganate)
- Value of standard, including correct units (e.g., $\text{KMnO}_4 = 1 \text{ mg/L}$)
- Link to information recorded according to section 5.1 above

5.2.7. Retain manufacturers' instrument specifications.

5.2.8. Document whether successful initial calibration occurred.

5.2.9. Document whether each calibration verification passed or failed.

5.2.10. Document any corrective actions taken to correct instrument performance according to records requirements of FD 3000.

5.2.10.1. Document date and time of any corrective action.

5.2.10.2. Note any incidence of discontinuation of use of the instrument due to calibration failure.

5.2.11. Describe or cite the specific calibration or verification procedure performed (DEP SOP or internal SOP).

5.3. Record all field-testing measurement data, to include the following:

- Project name
- Date and time of measurement or test (including time zone, if applicable)
- Source and location of the measurement or test sample (e.g., monitoring well identification number, outfall number, station number or other description)
- Latitude and longitude of sampling source location (if required)

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- Analyte or parameter measured
- Measurement or test sample value
- Reporting units
- Initials or name of analyst performing the measurement
- Unique identification of the specific instrument unit(s) used for the test(s).

FT 2020. TITRIMETRIC METHODS

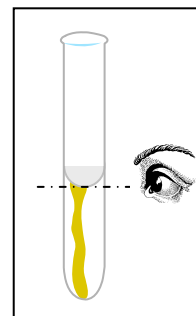
Residual chlorine can be measured using several different titrimetric methods. These methods take more time, require some skill in making chemical measurements, require several different reagents, and must be performed within 15 minutes of sample collection. Unless the expected concentration levels are below the analytical sensitivity of colorimeters, DEP recommends using the DPD colorimetric method (FT 2010).

If a titrimetric method must be used, select one of the following methods: SM 4500-Cl B, SM 4500-Cl C, SM 4500-Cl D, SM 4500-Cl E or SM 4500-Cl F. The following general discussions deal with using the titrimetric equipment only.

Quantitative and chronological brackets are not required for these methods.

Titration solutions must be standardized at the frequencies specified in the above reference methods.

1. The volumetric glassware that is used to transfer and to titrate must be thoroughly clean.
 - 1.1. Use class A pipets for transferring samples and reagents; use a class A buret for titration.
 - 1.2. The volumetric pipets and the buret must be free flowing. This means that there cannot be any droplets remaining on the sides of the glassware when the liquid is dispensed.
 - 1.3. Check the glassware before use by filling with de-ionized or distilled water and allowing to drain. Do not use the glassware if droplets appear.
 - 1.4. Clean by using a buret brush or soaking. Use hot water and laboratory detergent.
 - 1.5. Rinse with tap water to remove the detergent.
 - 1.6. Rinse with de-ionized water and check for water droplets.
 - 1.7. Additional cleaning with chromic acid, or alcoholic potassium hydroxide may be needed to remove stubborn oil or films.
2. Rinse all glassware with a small amount of the solution to be dispensed or titrated, and discard the rinse.
 - 2.1. Carefully fill (or pipet) with the solution.
 - 2.2. Read the volume from the **bottom** of the meniscus [see figure⇒].
 - 2.3. After filling the buret, record the initial volume.
3. When performing the titration, add the titrant slowly.
 - 3.1. Swirl the flask gently while adding the titrant.
 - 3.2. As the solution comes closer the endpoint, the color change will last for a longer period of time. When this occurs, add the titrant dropwise and mix thoroughly between drops.
 - 3.3. The reaction is complete when the color change is permanent. Take the reading on the buret at the completion of the titration and record the reading.
4. Titrate at least two aliquots of each sample.



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5. Titrate at least one blank.
6. DOCUMENTATION:
 - 6.1. Standard and Reagent Documentation: Document information about standards and reagents used for calibrations, verifications, and sample measurements.
 - 6.1.1. Note the date of receipt, the expiration date and the date of first use for all standards and reagents.
 - 6.1.1.1. Document acceptable verification of any standard used after its expiration date.
 - 6.1.2. Record the concentration or other value for the standard in the appropriate measurement units.
 - 6.1.2.1. Note vendor catalog number and description for preformulated solutions as well as for neat liquids and powdered standards.
 - 6.1.2.2. Retain vendor assay specifications for standards as part of the calibration record.
 - 6.1.3. Record the grade of standard or reagent used.
 - 6.1.4. When formulated in-house, document all calculations used to formulate calibration standards.
 - 6.1.4.1. Record the date of preparation for all in-house formulations.
 - 6.1.5. Describe or cite the procedure(s) used to prepare any standards in-house (DEP SOP or internal SOP).
 - 6.1.6. Record the preparation of all reagents in the field notebook or in a form specifically designed for this purpose.
 - 6.1.6.1. Document all titrant standardizations.- 7. For each sample and blank, record the volume of each sample, and the beginning and ending readings on the buret.

FT 2030. ION-SELECTIVE ELECTRODE METHODS

1. INTRODUCTION AND SCOPE: Adapted from the "Orion Research Instruction Manual", Residual Chlorine Electrode Model 97-70, 1997. This method may be used if a method detection limit study verifies that the method can achieve the desired permit limits. This is not recommended for on-site use.
2. EQUIPMENT AND SUPPLIES
 - 2.1. Instrument
 - 2.1.1. pH-millivolt meter capable of an expanded 0.1 mV reading.
 - 2.1.2. Platinum-iodide combination electrode (recommended) or
 - 2.1.3. A platinum and an iodide ion selective electrodes.
 - 2.1.4. Magnetic Stirrer
 - 2.2. Reagents and Standards

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- pH 4.0 Buffer
- Acetic acid
- Potassium Iodide Solution: Dissolve 42 g potassium iodide and 0.2 g sodium carbonate in 500 mL chlorine demand-free deionized/distilled water.
- Potassium iodate (Primary Standard – 0.00281 N): Dissolve 0.1005 g potassium iodate (KIO_3) in chlorine demand-free deionized/distilled water. Dilute to 1000 mL.

2.3. Recordkeeping and Documentation Supplies:

- Field notebook forms (waterproof paper is recommended) or
- Indelible pens

3. CALIBRATION AND USE

3.1. Standard Preparation: Prepare standards by volumetrically pipetting 0.2, 1.0, and 5.0 mL of the potassium iodate into 100 mL volumetric flasks.

3.1.1. Add 1 mL of the buffer and 1 mL potassium iodide solution to each.

3.1.2. Swirl and let stand for 2 minutes.

3.1.3. Bring to 100 mL, stopper and invert several times to mix.

3.1.4. Prepare a blank by adding all reagents except the potassium iodate to a 100 mL volumetric and bring the volume to 100 mL.

3.2. Initial Calibration: Follow manufacturer's instructions on the use of the instrument. Use the three standards and the blank to calibrate. Plot the curve on semilogarithmic graph paper or enter values into a direct-reading ion meter.

3.3. Verify the initial calibration before proceeding with sample analysis. Read at least one calibration standard as a sample. The measured value must be within 10% of the known value of the standard.

3.4. Continuing Calibration Verification: Use at least one of the standards to check the stability of the standard curve at the end of the analytical run or batch as in 3.3 above.

3.5. Follow the calibration and verification requirements in FT 1000, section 2.2.

3.6. Sample Analysis:

3.6.1. Adjust the pH of the sample with acetic acid to 4 – 5 pH units.

3.6.2. Pipet 1 mL buffer and 1 mL potassium iodide into a 100 mL volumetric flask. Swirl to mix and let stand for at least 2 minutes.

3.6.3. Bring to the volume to 100 mL with the pH-adjusted sample, stopper, and invert several times to mix.

3.6.4. Follow manufacturer's instructions for the use of the instrument.

3.7. Calculations:

3.7.1. Read the residual chlorine value in mg/L (R) from the calibration curve: mg/L residual chlorine = $R \times 100/\text{mL sample used}$

3.7.2. Record all calculations.

4. PREVENTIVE MAINTENANCE: Refer to FT 1000, section 3.

5. DOCUMENTATION:

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5.1. Standard and Reagent Documentation: Document information about standards and reagents used for calibrations, verifications, and sample measurements.

5.1.1. Note the date of receipt, the expiration date and the date of first use for all standards and reagents.

5.1.1.1. Document acceptable verification of any standard used after its expiration date.

5.1.2. Record the concentration or other value for the standard in the appropriate measurement units.

5.1.2.1. Note vendor catalog number and description for preformulated solutions as well as for neat liquids and powdered standards.

5.1.2.2. Retain vendor assay specifications for standards as part of the calibration record.

5.1.3. Record the grade of standard or reagent used.

5.1.4. When formulated in-house, document all calculations used to formulate calibration standards.

5.1.4.1. Record the date of preparation for all in-house formulations.

5.1.5. Describe or cite the procedure(s) used to prepare any standards in-house (DEP SOP or internal SOP).

5.2. Field Instrument Calibration Documentation: Document acceptable calibration and calibration verification for each instrument unit and field test or analysis, linking this record with affected sample measurements.

5.2.1. Retain vendor certifications of all factory-calibrated instrumentation.

5.2.2. Designate the identity of specific instrumentation in the documentation with a unique description or code for each instrument unit used.

5.2.2.1. Record manufacturer name, model number, and identifying number such as a serial number for each instrument unit.

5.2.3. Record the time and date of all initial calibrations and all calibration verifications.

5.2.4. Record the instrument reading (value in appropriate measurement units) of all calibration verifications.

5.2.5. Record the name of the analyst(s) performing the calibration.

5.2.6. Document the specific standards used to calibrate or verify the instrument or field test with the following information:

- Type of standard or standard name (e.g., potassium permanganate)
- Value of standard, including correct units (e.g., $\text{KMnO}_4 = 1 \text{ mg/L}$)
- Link to information recorded according to section 5.1 above

5.2.7. Retain manufacturers' instrument specifications.

5.2.8. Document whether successful initial calibration occurred.

5.2.9. Document whether each calibration verification passed or failed.

5.2.10. Document any corrective actions taken to correct instrument performance according to records requirements of FD 3000.

5.2.10.1. Document date and time of any corrective action.

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5.2.10.2. Note any incidence of discontinuation of use of the instrument due to calibration failure.

5.2.11. Describe or cite the specific calibration or verification procedure performed (DEP SOP or internal SOP).

5.3. Record all field-testing measurement data, to include the following:

- Project name
- Date and time of measurement or test (including time zone, if applicable)
- Source and location of the measurement or test sample (e.g., monitoring well identification number, outfall number, station number or other description)
- Latitude and longitude of sampling source location (if required)
- Analyte or parameter measured
- Measurement or test sample value
- Reporting units
- Initials or name of analyst performing the measurement
- Unique identification of the specific instrument unit(s) used for the test(s)

FT 2040. SCREENING METHOD TO DETERMINE THE ABSENCE OF RESIDUAL CHLORINE

1. INTRODUCTION AND SCOPE: In some cases, wastewater treatment plants may need to determine the complete absence of residual chlorine after dechlorination. Some metered instruments may not have sufficient sensitivity to measure below 0.2-mg/L. This procedure was developed by Region 4 of the Environmental Protection Agency to be used to **determine, but not report** the absence of residual chlorine.

2. METHOD: Use any residual chlorine method. If a colorimetric method (FT 2010) is used, the spectrophotometer or colorimeter must be able to distinguish between 0.02 and 0.05 mg/L chlorine. To document the sensitivity, perform a method detection limit study to verify that the method detection limit is at least 0.02 mg/L.

3. PROCEDURE:

See Figure FT 2000-1

3.1. If used, calibrate the meter following FT 2010. Otherwise, use a titrimetric method (FT 2020).

3.2. Perform all tests within 15 minutes of collecting the samples.

3.3. Collect a grab sample at a point just before dechlorination or the effluent of the chlorine contact basin. This is sample **A**.

3.4. Collect a second grab sample after dechlorination. This should correspond to the final effluent monitoring point (sample **B**).

3.4.1. Sample **A** and Sample **B** must differ only by the dechlorination treatment. **There cannot be any waste streams that enter the system between the two collection points.**

3.5. Measure and pour equal volumes of Sample **A** and Sample **B** into a clean container that can be sealed. Use a container that leaves little or no headspace when filled. This is sample **C**.

3.5.1. Cap and gently invert the container (sample **C**) several times to mix the contents. **Do not shake vigorously.**

3.6. Measure the total residual chlorine in samples **A** and **C**.

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3.7. Calculate the concentration in sample **B**:

$$\text{Residual Chlorine in } \mathbf{B} \text{ (mg/L)} = [\mathbf{C}^2] - \mathbf{A}$$

3.8. The absence of residual chlorine is verified if the residual chlorine in **B** is less than or equal to $\frac{1}{2} \mathbf{A}$. 1.10. Refer to figure FT 2000-1 for illustrative examples.

3.9. If the value results in a negative number and a sulfite salt (e.g., sodium bisulfite, sodium metabisulfite) was used to dechlorinate the effluent, less dechlorination agent can be added.

4. DOCUMENTATION: Document the following items as applicable.

4.1. Standard and Reagent Documentation: Document information about standards and reagents used for calibrations, verifications, and sample measurements.

4.1.1. Note the date of receipt, the expiration date and the date of first use for all standards and reagents.

4.1.1.1. Document acceptable verification of any standard used after its expiration date.

4.1.2. Record the concentration or other value for the standard in the appropriate measurement units.

4.1.2.1. Note vendor catalog number and description for preformulated solutions as well as for neat liquids and powdered standards.

4.1.2.2. Retain vendor assay specifications for standards as part of the calibration record.

4.1.3. Record the grade of standard or reagent used.

4.1.4. When formulated in-house, document all calculations used to formulate calibration standards.

4.1.4.1. Record the date of preparation for all in-house formulations.

4.1.5. Describe or cite the procedure(s) used to prepare any standards in-house (DEP SOP or internal SOP).

4.2. Field Instrument Calibration Documentation: Document acceptable calibration and calibration verification for each instrument unit and field test or analysis, linking this record with affected sample measurements.

4.2.1. Retain vendor certifications of all factory-calibrated instrumentation.

4.2.2. Designate the identity of specific instrumentation in the documentation with a unique description or code for each instrument unit used.

4.2.2.1. Record manufacturer name, model number, and identifying number such as a serial number for each instrument unit.

4.2.3. Record the time and date of all initial calibrations and all calibration verifications.

4.2.4. Record the instrument reading (value in appropriate measurement units) of all calibration verifications.

4.2.5. Record the name of the analyst(s) performing the calibration.

4.2.6. Document the specific standards used to calibrate or verify the instrument or field test with the following information:

- Type of standard or standard name (e.g., potassium permanganate)
- Value of standard, including correct units (e.g., $\text{KMnO}_4 = 1 \text{ mg/L}$)
- Link to information recorded according to section 5.1 above

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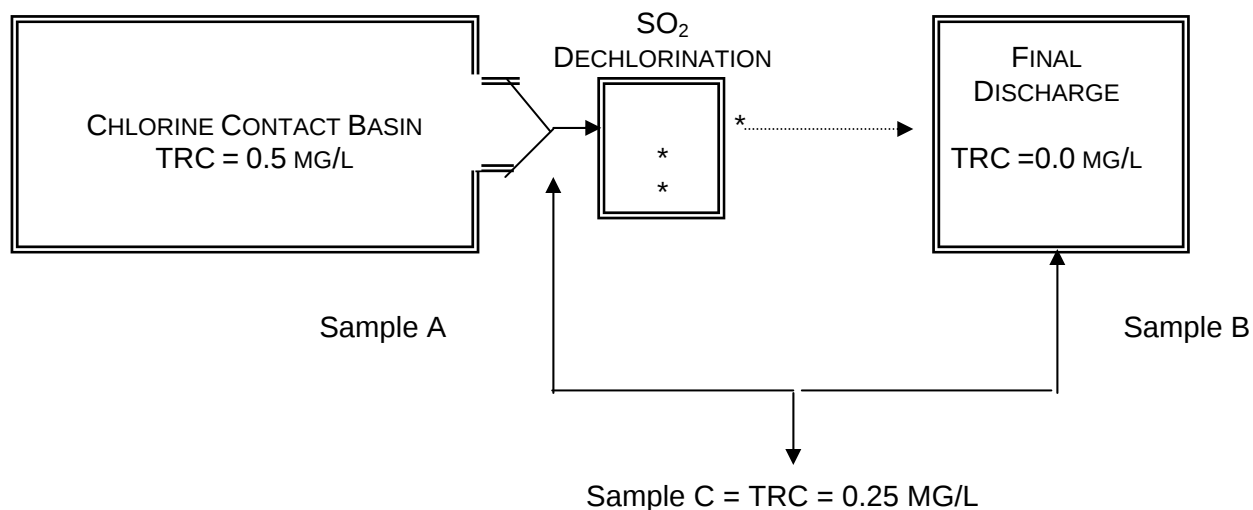
- 4.2.7. Retain manufacturers' instrument specifications.
- 4.2.8. Document whether successful initial calibration occurred.
- 4.2.9. Document whether each calibration verification passed or failed.
- 4.2.10. Document any corrective actions taken to correct instrument performance according to records requirements of FD 3000.
 - 4.2.10.1. Document date and time of any corrective action.
 - 4.2.10.2. Note any incidence of discontinuation of use of the instrument due to calibration failure.
- 4.2.11. Describe or cite the specific calibration or verification procedure performed (DEP SOP or internal SOP).
- 4.3. Record all field-testing measurement data, to include the following:
 - Project name
 - Date and time of measurement or test (including time zone, if applicable)
 - Source and location of the measurement or test sample (e.g., monitoring well identification number, outfall number, station number or other description)
 - Latitude and longitude of sampling source location (if required)
 - Analyte or parameter measured
 - Measurement or test sample value
 - Reporting units
 - Initials or name of analyst performing the measurement
 - Unique identification of the specific instrument unit(s) used for the test(s)

Appendix FT 2000
Tables, Figures and Forms

Figure FT 2000-1 Screening Method for Determining Absence of Residual Chlorine

Figure FT 2000-1

SCREENING METHOD FOR DETERMINING ABSENCE OF RESIDUAL CHLORINE



A = Grab sample collected just prior to dechlorination.

B = Grab sample collected downstream of dechlorination at final discharge point.

C = Equal volumes of A & B mixed without aeration and the expectant

$$\text{TRC concentration mg/L} = \frac{A + B}{2} = \frac{0.5 + 0.0}{2} = 0.25$$

If $1/2 A = C$, then the TRC at Sample B = <0.01 or the MDL value determined on the instrument whichever was greater.

If $1/2 A > C$, then excess SO₂ was added. The TRC concentration would be <0.25 mg/L at Sample C and the TRC for Sample B = 0.0 mg/L and would be reported as a $<$ value.

If $C > 1/2 A$, then Sample B would have TRC present in final effluent. To calculate the Sample B value: $[C * 2] - A = \text{TRC concentration}$. Example: If the TRC concentration of C = 0.27 and A = 0.5, then 0.