

Distribution Systems Operation and Management

Operational Guide to AWWA Standard G200

G200



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Operational Guide to AWWA Standard G200 Distribution Systems Operation and Management

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SECTION 1: ACKNOWLEDGMENTS

Special thanks are extended to Jaala Draper who provided the technical review for this publication. Also appreciation is extended to Jane Byrne, Patricia Moore, and Kevin Whitsett for their contributions.

Thank you, too, to the committees and volunteers that helped conceive the framework and develop the series of standards that led to the creation of this guidebook, particularly Eva Nieminski, Jim Ginley, and Todd Humphrey for their reviews and passion for excellence in water quality and operations.

SECTION 2: FOREWORD

This operational guide has been written as a guidance tool for the implementation of water distribution systems operation and management (O&M) best practices, as set forth in ANSI/AWWA G200, *Distribution Systems Operation and Management* (AWWA G200). AWWA G200 is part of the voluntary G-series of standards for water utilities, initially established in 2004.

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from more than 10 North American utilities. The pilot project assessed the applicability and practicality of the series of AWWA Utility Management Standards by working with two utilities—Birmingham (Ala.) Water Works and Sewer Board and Washington County (Va.) Service Authority—and a team of volunteers from utilities, consulting firms, and other organizations.

During the pilot process, the utility managers requested that AWWA develop some type of guidance or “how to” documents to go along with the G-series standards. These guidance documents would serve two purposes: one, to help utility managers understand the purpose and function of these new standards, and two, help them implement and incorporate the standards into everyday operations. From this suggestion the series of operational guides was conceived.

This guidebook is the first of the series that will be developed to correspond with the appropriate G-series standard.

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Just as important as the quality of the water supplying the distribution system is the quality of O&M used to maintain that system. If the infrastructure used to transport water to customers is allowed to deteriorate and operate without any level of standards, the quality of the water delivered cannot be guaranteed safe for consumption, let alone of high quality.

The US Environmental Protection Agency’s (USEPA’s) Safe Drinking Water Act ensures public safety by setting extensive regulatory requirements for public water suppliers. However, progressive utilities may voluntarily subscribe to additional requirements, such as the AWWA G-series of standards, in order to take a more proactive approach to guarantee that a high-quality product, which exceeds regulatory requirements, reaches the consumers’ taps.

ANSI/AWWA G200, *Distribution Systems Operation and Management*, is based on water distribution system O&M best practices, developed by consensus of the AWWA Standards Committee. AWWA G200 also calls for quality O&M of distribution systems through the appropriate expertise of those operating and managing the system. This guidebook has been established to assist any water distribution utility, large or small, in adopting those practices set forth in AWWA G200.

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This guidebook breaks AWWA G200 down into the following components:

Standard Language—The Standard Language is wording from a section of AWWA G200, as written in the latest standard document. In this guidebook, the standard language is shaded in gray.

Rationale—The Rationale provides background on the topic in each section of the standard and relevance to why the requirements are important for water distribution utilities.

Example of Methods or Procedures—The Examples given do not cover every aspect of the standard and will not apply to every utility's situation. Additionally, they are not intended to be a complete instruction guide for the implementation of AWWA G200, rather they are intended to point interested parties in the right direction and give insight on how processes and procedures may be properly implemented in accordance with parts of the standard. In order to maintain this publication at a reasonable size, only a handful of examples per topic are included, and most point to a secondary publication with current standard operating procedures and practices used by a handful of select utilities in a standardized format. There are also many sources of additional information listed in the References and Resources section (Sec. 6).

Questions to Check Progress—The Questions are listed as a tool to self-assess the status of the utility's compliance with AWWA G200. If the utility can confirm that they have all items in the questions in place, they may wish to consider applying for recognition.

The Audit Checklist in Sec. 7 is included to further assist utilities in performing an initial gap analysis or assessing their progress in implementing AWWA G200. This tool will help identify any gaps that may exist in their current procedures and those required to meet the standard. It asks specific questions and looks for proof and documentation that procedures are indeed in place where called for by the standard. Just as the examples are not an instruction manual for implementing all of AWWA G200, neither is the checklist a blueprint. However, a utility that has all the components represented in the checklist is likely to have a majority of the G200 standard well covered in their operating and management procedures and practices.

SECTION 4: REQUIREMENTS

Sec. 4.1 Water Quality

4.1.1

Compliance With Regulatory Requirements

The utility shall determine and document all local, state, provincial, federal, or other regulations that apply to their utility. The utility shall meet or exceed all applicable regulations.

Rationale

Customers associate health and safety issues related to drinking water directly to the utility's ability to meet all local, state, provincial, federal, or other regulatory requirements to which the utility subscribes. It is absolutely necessary for the utility to meet or exceed all applicable regulations to gain the confidence of the consuming customers. To comply with these requirements, the utility shall establish and maintain procedures to identify and have access to the applicable legal and regulatory requirements to which the utility subscribes related to its scope and operation. The utility shall ensure that these applicable legal and regulatory requirements are taken into account in establishing, implementing, and maintaining its water quality management system.

This can be accomplished by the utility developing a legal and other regulatory requirements list and ensuring this list is periodically reviewed and updated. The utility shall also document how these requirements are adhered to in its operation.

Example of Methods or Procedures

Following is a sample of a regulatory and other requirements form that can be used by a utility to identify and maintain a listing of the most up-to-date versions of all regulatory and other requirements that apply to their system.

Title: Regulatory and Other Requirements Form

Purpose/Scope: This document is used to identify and record legal and other requirements to which the utility subscribes that have been identified as being directly applicable to the utility's activities, products, and services. Completion of this document will aid overall management of the water quality.

Instructions: This document (Figure 4.1.1) is to be updated as regulatory and other requirements are modified, added, or removed. At the title of the

Prepared By/Date:			
Title of Rule, Regulation, or Law	General Subject Covered	Responsibility for Current Version	Document Format/ Location (If Electronic, Provide Web Address)

Figure 4.1.1 Regulatory and Other Requirements Form

requirement and provide a brief description in the column titled: General Subject Covered. Rules, regulations, and laws must be periodically reviewed for current version and updates; therefore, identify which part of the utility will perform this review in the column titled: Responsibility for Current Version. Establish electronic links in the column titled: Document Format/Location. This ensures that the most current requirements are available for reference. With hard-copy requirements, list the location(s) of the hard-copy.

All utility departments are required to ensure that regulatory and other requirements are interpreted and applied to their operations. Those listed as “Responsible” are required to periodically ensure that the most recent legal and other requirements are identified and listed. **NOTE:** This form may be replicated on a computer or duplicated on a photocopier. The computer copy must look similar to this document and contain the same information.

Questions to Check Progress

1. Does the utility have an established list of updated legal and regulatory requirements?
2. Has the utility communicated this information to all the stakeholders and established systems to periodically review and update this form?
3. Has the utility established programs to ensure regulatory requirements are adhered to?
4. Has the utility established a system of monitoring to ensure compliance to the legal and regulatory requirements and to ensure water quality in the distribution system?

4.1.2 Monitoring and Control

- 4.1.2.1 Sampling plan. The utility shall establish a routine distribution system sampling plan that is representative of the entire distribution system. The sampling plan shall be reviewed annually and adjustments made based on historical data trends, changes in water use patterns, or other changes that may affect water quality. The utility shall analyze data trends and have an action plan to respond to changes.
- 4.1.2.2 Sample sites. Sample sites shall include, at a minimum, sites required for regulatory compliance monitoring. Additional sites shall be sampled as necessary to provide a complete picture of water quality in the system. The utility shall use sampling sites that are representative of all known distribution system conditions, including the following: variations in hydraulic detention time, pipeline materials, where booster disinfection is applied, where water is stored, and where water quality deterioration (e.g., loss of disinfectant residual and increased microbial growth) is known, or suspected, to occur. Samples shall include locations that represent the longest detention time in the system, dead-end locations, areas of low circulation, and finished water storage facilities. Locations where problems have occurred in the past require more frequent sampling.
- 4.1.2.3 Sample collection. Samples shall be collected in accordance with *Standard Methods for the Examination of Water and Wastewater*. Chain of custody forms shall be used throughout the sampling process in accordance with *Standard Methods for the Examination of Water and Wastewater* or regulatory requirements. Both sample collectors and the laboratory shall use standardized labels and forms.
- 4.1.2.4 Sample taps. Sample taps shall be protected from outside sources of contamination. The integrity of the sample taps shall be evaluated annually to correct leaks or other potential sources of contamination.

Rationale

Water quality monitoring in the distribution system provides information on water quality conditions between the entry point to the system and the customer's tap. It guides the utility in making changes in operations, maintenance, or treatment to improve overall water quality before water reaches the customer. The most common monitoring parameters used for distribution system water quality include coliform bacteria; chlorine residual; heterotrophic plate count (HPC) bacteria; pH; turbidity; disinfection by-products (DBPs); color, and odors; pressure; and water temperature.

Sampling for water quality within the distribution system is required by law and a sampling plan will ensure that the utility will meet or exceed all sampling requirements when it is properly established. Selecting appropriate sample sites throughout the distribution system will ensure that the samples will be representative of the entire system and that water quality conditions are acceptable throughout. It is important to determine locations in the system where water quality is more likely to be problematic and sample regularly at those sites. These locations include, but are not limited to, dead ends, areas of low circulation, and extreme outlying points in the distribution system, where disinfectant residual is more likely to be low and poor water quality conditions could easily develop. Sampling at these predetermined locations at regular intervals will ensure that the water quality is being maintained there and throughout the rest of the system.

Written procedures for proper field sampling, sample collection, and sample handling will ensure that all sampling results will be accurate and truly representative of the distribution system. All associates who may be expected to perform sample collection and/or analysis need to be fully trained on these procedures to ensure sample integrity and results.

Routine inspection of all sample taps is critical to obtaining accurate water quality samples. Sample taps can be inspected continuously as they are accessed for sampling, but annual inspections should be conducted at a minimum to ensure that they are still accessible, safe from contamination, and in good condition.

Example of Methods or Procedures

Following is a method for water quality sampling procedures, instructing associates on the proper sampling, field testing, handling, and processing procedures to follow. Associates who are responsible for performing any sampling and/or field testing must be trained on these procedures.

Title: Water Quality Sampling

Purpose and Scope: To provide guidance, steps, and instructions on field testing and collection of water quality samples in compliance with the Safe Drinking Water Act for all types of water quality parameters within the distribution system.

Responsibility and Authority: All associates performing water quality testing and/or sampling shall fully and completely ensure that all samples are collected in compliance with the Safe Drinking Water Act. The water quality technician will ensure proper maintenance and annual review of the sample site plan, proper calibration of all field testing units, and availability of current forms.

Work Steps: Water Quality Field Testing—Turbidity Level Testing

1. Collect a sample from a hydrant or faucet in a clean container. Fill sample bottle to the 15-mL line.
2. Wipe the sample bottle with a soft, lint-free cloth to remove water spots and fingerprints. Always use clean sample bottles.
3. Apply one drop of silicone oil to the outside of the sample bottle and wipe with a soft cloth to obtain an even film over bottle.
4. Turn the turbidity meter instrument on at the “I/O” switch.
5. Make sure that the instrument is on a flat, sturdy surface.
6. Allow air bubbles to settle out of the sample bottle.
7. Place sample bottle in the instrument so that the diamond mark aligns with the raised mark in front of the compartment.
8. Press “READ” and the instrument will display “NTU.” Record the turbidity after the lamp turns off.
 - If a sample causes an unstable reading, hit the “SIGNAL AVERAGE” button and then the “READ” button again, which will measure the sample 10 times within ± 20 seconds.
 - Signal averaging uses more power and should only be used under unstable reading conditions.
9. When turbidity testing is complete, clean all equipment, flush out sample bottle with distilled water, and secure equipment within the case.
10. Log data on appropriate form and/or database.

One way to ensure sample tap integrity is to institute sample tap inspections into the daily duties of the associate(s) responsible for performing routine sampling of the distribution system. Each sample tap can be inspected every time it is visited for sample collection.

Questions to Check Progress

1. Does the utility have a representative distribution system water quality sampling plan that meets or exceeds the regulatory requirements?
2. Does the utility review and update the water quality sampling plan annually, or earlier when major changes occur in the distribution system, to ensure it remains representative of the distribution system?

3. Does the utility have written sampling standard operating instructions to meet the requirements of the standard's methods and local regulatory agencies in time of collection, transportation, and chain of custody requirements?
4. Does the utility identify, install, and maintain the sampling locations at least annually to ensure that those sites are prevented from possible contamination?

4.1.3

Disinfectant Residual Maintenance

(Sec. 4.1.3 does not apply to distribution systems not utilizing a residual disinfectant.)

4.1.3.1

Disinfectant residual. The utility shall maintain a detectable disinfectant residual or a heterotrophic bacteria (or plate) count (HPC) of 500 or fewer colony forming units per mL at all points in the distribution system at all times. The utility shall monitor and record disinfectant residual or HPC as described in the sampling plan (Sec. 4.1.2.1).

4.1.3.2

Nitrification control. If the utility adds ammonia to the water as part of the disinfection process or if there is a significant concentration of ammonia in the source water, the following procedures shall be used:

- a. Monitoring of the free ammonia concentration prior to and after chloramination. The weight ratio of chlorine to ammonia must be monitored and controlled to minimize the presence of free ammonia in the system.
- b. Adjustment of the ammonia feed rate to compensate for the source water ammonia concentration, or the ammonia is oxidized prior to chloramination. Establish and periodically review a disinfectant goal based on the historical database to avoid nitrification.

4.1.3.2.2

The utility shall routinely monitor for other key nitrification indicator parameters (i.e., nitrite, nitrate, and free ammonia).

4.1.3.3

Booster disinfection. (Sec. 4.1.3.3 does not apply to distribution systems not utilizing a residual disinfectant or that do not employ booster disinfection.)

4.1.3.3.1

The utility shall set and document residual goals and a program to monitor compliance with goals as detailed in Sec. 4.1.3.1.

4.1.3.3.2

The utility shall have clear operating procedures for each booster disinfection facility based on maintaining residual goals at critical points. Plans should take into account seasonal variations, water quality, flow, and system operation variations.

- 4.1.3.3.3 The utility shall have a written plan to respond to any variance between operational goals and actual measured results.
- 4.1.3.4 Disinfection by-product monitoring and control.
 - 4.1.3.4.1 The utility shall have a program to monitor and control disinfection by-products. The program shall establish goals for DBPs at critical points in the distribution system.
 - 4.1.3.4.2 The utility shall have an action plan to respond to DBP problems in the distribution system. This plan shall include specific actions to take should the DBP levels exceed the established goals.

Rationale

The disinfection of drinking water has been hailed as one of the most important advances ever in the protection of public health. In the United States and other developed countries, drinking water disinfection has all but eliminated serious waterborne diseases that still kill tens of millions of people each year in other parts of the world.

In North America, chlorine residual is probably the second most important parameter in the distribution system. In addition to its regulatory importance, its function as a surrogate for the condition and health of the distribution system is widely held. For example, chlorine residual information is helpful in identifying areas of the distribution system with a high disinfectant demand due to long hydraulic detention times or microbial regrowth problems. Chlorine, in some form, is the only disinfectant known that can provide a continuing level of disinfection (known as *secondary* or *residual disinfection*) after water has left the treatment plant and enters the distribution system. HPC bacteria monitoring provides a general measure of bacterial water quality in the distribution system. It may be used in place of disinfectant residual to meet certain Surface Water Treatment Rule (SWTR) requirements.

All disinfectants create a complex family of by-product compounds, some of which are of human health concern, and are now regulated by USEPA. For example, both gaseous chlorine and sodium hypochlorite react with organic material in water to form chlorinated organic compounds. In response to this, many drinking water utilities in the United States are implementing chloramination for distribution system disinfection to minimize formation of the two major types of DBPs, trihalomethanes (THMs) and haloacetic acids (HAAs). However, there is a significant concern associated with chloramination—nitrification. Nitrification

is caused by the growth of ammonia-oxidizing bacteria (AOB) in the distribution system. AOB use ammonia as an energy source, converting ammonia to nitrite. Nitrite speeds the decomposition of the chloramine residual, the disappearance of which can increase HPC bacteria and coliforms. Reduced residual levels also may cause a utility to violate disinfectant residual requirements.

Most of the studies of DBPs in drinking water over the past 30 years have been conducted in laboratories under controlled, uniform conditions. Little is known about changes in DBP concentrations and speciation that can take place in actual distribution systems, where DBP formation can be affected by pipe walls, biofilms, flow rates, residence time, changing storage tank levels, booster chlorination, and free chlorine residuals. That is why careful monitoring around areas of known variances, such as booster chlorination stations, is so critical.

Every utility must balance their use of disinfection chemicals with the formation of harmful DBPs. Monitoring and control plans must be established and implemented in order to do so.

Example of Methods or Procedures

Example 1

Standard procedures can include guidelines for chlorine residual monitoring. The following is one example of a standard procedure that includes chlorine residual monitoring.

Title: Chlorine Residual Monitoring

Chlorine Level Testing

- Zero out the chlorine meter (NOTE: Zeroing must be done prior to every test):
 1. Fill a clean sample bottle to the 10-mL mark with the same solution as being tested.
 2. Wipe excess liquid off sample cells or damage to the instrument may occur.
 3. Place the water-filled sample in the cell compartment with the diamond mark facing the front of the instrument. Cover the sample bottle with the instrument cap.
 4. Ensure the cap is placed over the sample with the curved surface facing the keyboard.
 5. Press the "ZERO" key.
 6. After approximately two (2) seconds, the display will read "0.00."
- Using the Hach Pocket Colorimeter (NOTE: Samples must be analyzed immediately on-site):

1. Fill a 10-mL sample bottle with the sample to be tested.
2. Add the contents of two DPD Total Chlorine Powder Pillows to the sample bottle. Cap and gently shake for 20 seconds.
3. Wipe excess liquid off sample cells or damage to the instrument may occur.
4. Wait three minutes, then place the sample bottle into the cell holder.
NOTE: A pink color will form if chlorine is present.
5. Tightly cover the cell with the instrument cap.
6. Press "READ."
7. The instrument will show "___ mg/L" total chlorine.

Work Completion:

1. Chlorine readings within the water distribution system should be between 1.0 and 3.0. If levels obtained are not within this range, then flushing may be required. Contact the senior manager for direction.
2. When chlorine testing is complete, clean all equipment, flush out sample cell with distilled water, and secure equipment within the case.
3. Log data on appropriate form and/or database (Figure 4.1.3).

In addition to regulatory sampling of the system, chlorine residuals should be routinely monitored at dead ends and other trouble areas that have been identified throughout the system.

Example 2

The following procedure is an example of how one system attempts to control nitrification. This does require steps to be taken by other parts of the system besides distribution, as it is a whole-system approach.

Annual Blow-Off Monitoring Schedule							
_____ Quarter							
Location (address)	Size (in.) [cm]	Date (mm/dd/yy)	Chlorine Residual		Turbidity		Consumption (gal) [m ³]
			Pre-flush	Post-flush	Pre-flush	Post-flush	
						Total Consumption:	0

Figure 4.1.3 Annual Blow-Off Monitoring Schedule Form



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Title: Nitrification Prevention

Purpose: Outline protocols and chemical treatments to minimize the potential for nitrification in the distribution system

Responsibility and Authority: Process Control/Shift Supervisors

Work Steps:

1. Control chlorine-to-ammonia ratio in 3:1 to 4:1 range. If ratio exceeds 5:1, notify Director/Assistant Director. Total chlorine and ammonia fed to Booker and Stoney is displayed on SCADA—also check monthly chemical inventories for usage as well as log sheets for daily feed.
2. If SCADA Hi or Hi Hi alarm goes off based on Chemscan free ammonia sensor, check that chlorine and ammonia feed systems are operating correctly—notify Director/Assistant Director.
3. Chlorine dioxide, as well as being an excellent disinfectant, produces chlorite as a by-product. Chlorite has been shown to inhibit growth of bacteria that cause nitrification. Ensure chlorine does not exceed the maximum contaminant level (MCL) as it is regulated.
4. Monitor turnover of storage tanks. Typically 3–4 days to completely turn a tank is adequate, but during hot, wet weather, more aggressive tank turning may be necessary (>60 percent per day).
5. Have lab take samples and measure nitrite/nitrate on weekly basis, especially during hot, wet weather when tank turnover may be an issue.
6. Monitor combined chlorine levels in tanks—if it starts to trend down from a normal range of 2–2.5, call Plant Director.
7. Monitor combined chlorine throughout system—if it falls below 0.5 (verify by grab), call Plant Director and distribution personnel to initiate flushing.
8. Coordinate with Planning Department when tank cleaning task instructions are issued (typically 3–5 year cycle).

Example 3

AWWA M20, *Water Chlorination/Chloramination Practices and Principles*, recommends three different strategies for booster, or secondary, chlorination for utilities with chloraminated water.

- Add free chlorine to combine with residual ammonia. The procedure uses residual free ammonia remaining in the water as a consequence of chloramine decay. Chlorine is added in the ratio of 4:1 to 5:1 (chlorine: