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American Water Works
Association

ANSI/AWWA C653-13
(Revision of ANSI/AWWA C653-03)

AWWA Standard

Disinfection of Water Treatment Plants

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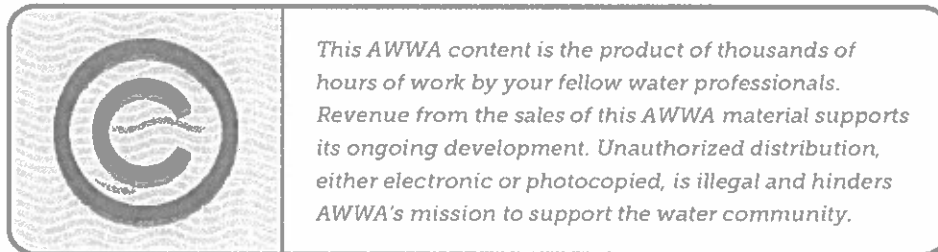
AWWA Standard

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Foreword

This foreword is for information only and is not a part of ANSI/AWWA C653.

I. Introduction.

I.A. *Background.* This standard describes methods of disinfecting new treatment facilities before they are placed in service; existing treatment facilities before they are returned to service after construction, inspection, or other event causing potential contamination; and existing treatment facilities that, under normal operation, continue to demonstrate the presence of total coliform bacteria in the plant effluent. Because of the complexity and diversity of treatment plants, the formulation of firm rules for application of this standard is not practicable. Nevertheless, principles described in this standard do apply generally and must be followed to enable proper disinfection of treatment plant facilities. Several alternative disinfection procedures are provided for those parts of the treatment plant generally referred to as conveyance facilities (such as pipes) and storage facilities (such as basins, tanks, or clearwells).

Disinfection is required for all portions of the facility that are downstream from the filter influent or that are downstream from the first point of disinfectant application in the treatment process when the water is disinfected prior to filtration, as described in Sec. 4.2. That part of the treatment facility handling raw water need not be disinfected but should be thoroughly cleaned as described in Sec. 4.1.

I.B. *History.* The first edition of ANSI/AWWA C653 was approved by the AWWA Board of Directors on Jan. 25, 1987. The second edition of ANSI/AWWA C653 was approved on Feb. 2, 1997. The third edition was approved Jan. 19, 2003. This edition was approved on June 9, 2013.

II. Special Issues.

II.A. *Alternative Disinfection Procedures.* The utility should decide which of the alternative disinfection procedures is most suitable for a given situation. Choice of the procedure used should include consideration of the availability of materials and equipment for the disinfection operation, the training of personnel to perform the disinfection, and safety considerations. For example, gas chlorination should be used only where properly designed and constructed equipment is available; makeshift equipment is not acceptable when liquid chlorine gas cylinders are used. Spray equipment should be used inside tanks or enclosures only when thorough ventilation

* American National Standards Institute, 25 West 43rd Street, Fourth Floor, New York, NY 10036.

is assured or when appropriate protection for personnel is provided. If a procedure is selected that requires the disposal of highly chlorinated water, thorough consideration should be given to the impact on the environment. If there is any question that the discharge of chlorinated waste may cause damage to aquatic life, wildlife, human health, physical installations, or other downstream water uses of any type, a reducing agent should be applied to water being disposed of to thoroughly neutralize the chlorine residual remaining in the water. Refer to ANSI/AWWA C655 Field Dechlorination for appropriate dechlorination requirements.

Disinfection of treatment plants requires high levels of disinfectant to be applied to ensure bacteria and other potential pathogens are inactivated. It should be noted that pH and temperature are two important factors affecting the disinfectant process. Above pH 9, chlorine is in the form of hypochlorite, which is not as effective a disinfectant as hypochlorous acid, which is more prevalent at pH less than 9. Water temperature also affects the disinfection process; disinfection at low temperatures is not as effective as at high temperatures.

Disinfectants other than chlorine may be appropriate to use. While this standard describes only the use of liquid chlorine, sodium hypochlorite solutions, and calcium hypochlorite, the applicability of other disinfectants should be evaluated. Ozone and chemical cleaners have been used, and these warrant further investigation. Whichever disinfectant or method is selected, approval from the local regulatory agency may be required.

III. Use of This Standard. It is the responsibility of the user of an AWWA standard to determine that the products described in that standard are suitable for use in the particular application being considered.

III.A. Purchaser Options and Alternatives. The following information should be provided by the purchaser:

1. Standard used—that is, ANSI/AWWA C653, Standard for Disinfection of Water Treatment Plants, of latest revision.
2. Whether compliance with NSF/ANSI 60, Drinking Water Treatment Chemicals—Health Effects, is required.
3. Details of other federal, state or provincial, and local requirements (Sec. 4.1).
4. Form of chlorine to be used (Sec. 4.3).
5. Method of chlorination of piping (Sec. 4.4.1).
6. Precautions for disposal of chlorinated water (Sec. 4.4.4.4).
7. Bacteriological testing method to be used (Sec. 5.1).

8. Redisinfection, if required (Sec. 5.1).
9. Method of dechlorination, if required.

III.B. *Modification to Standard.* Any modification of the provisions, definitions, or terminology in this standard must be provided by the purchaser.

IV. Major Revisions. Major changes made to the standard in this revision include the following:

1. The Special Issues section of the foreword has been updated to include a note to the user on the effect of pH and temperature on the disinfection process, as well as a note on consideration of alternative disinfectants (Foreword Section II).
2. Definitions for available chlorine, free chlorine, chlorine residual, contractor, liquid chlorine, and purchaser have been added (Section 3).
3. A requirement for compliance with the Safe Drinking Water Act has been added (Section 4).
4. Additional clarification and guidance on water treatment plant components requiring disinfection has been added (Sec. 4.2).
5. Reference to ANSI/AWWA B301 for Liquid Chlorine and ANSI/AWWA B300 for Hypochlorites has been added (Sec. 4.3).
6. An advisory note on using appropriate personal protective equipment when handling chlorine products has been added (Sec. 4.3).
7. An advisory note on perchlorate formation in hypochlorites has been added (Sec. 4.3.2).
8. Reference to ANSI/AWWA C655 for field dechlorination practices has been added (Sec. 4.4.4.4).
9. An advisory note on testing a disinfected facility not immediately returned to service has been added (Sec. 5.1).
10. Appendix A on Disposal of Heavily Chlorinated Water has been removed. This information is now covered in more detail in ANSI/AWWA C655, Field Dechlorination.

V. Comments. If you have any comments or questions about this standard, please call AWWA Engineering and Technical Services at 303.794.7711, FAX at 303.795.7603, write to the department at 6666 West Quincy Avenue, Denver, CO 80235-3098, or email at standards@awwa.org.

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ANSI/AWWA C653-13
(Revision of ANSI/AWWA C653-03)

AWWA Standard

Disinfection of Water Treatment Plants

SECTION 1: GENERAL

Sec. 1.1 Scope

This standard describes chlorination materials, procedures, and requirements for disinfection of new treatment facilities and existing water treatment facilities temporarily taken out of service for cleaning, inspection, maintenance, painting, repair, or any other activity or event that might lead to contamination of water. Typically, this standard applies to treatment components, including filter basins, filter media, clearwells, pump suction wells, and associated piping and appurtenances located downstream from the filter influent or from the first point of application of disinfectant in the treatment process. The disinfection method employed is surface contact with a high-strength chlorine solution for a specific time period. The absence of total coliform bacteria in addition to the use of proper disinfection practices is confirmation that the disinfection process has been accomplished in compliance with the standard.

Sec. 1.2 Purpose

The purpose of this standard is to define the minimum requirements for the disinfection of water treatment plants, including facility preparation, application of chlorine to the interior surfaces of water treatment units, and sampling and testing for the presence of total coliform bacteria.

Sec. 1.3 Application

This standard can be referenced in specifications for the disinfection of water treatment plants and can be used as a guide for facility preparation, application of chlorine, and sampling and testing for the presence of total coliform bacteria. The stipulations of this standard apply when this document has been referenced and then only to the disinfection of water treatment plants.

SECTION 2: REFERENCES

This standard references the following documents. In their latest editions, they form a part of this standard to the extent specified within the standard. In any case of conflict, the requirements of this standard shall prevail.

- ANSI/AWWA B100—Granular Filter Material.
- ANSI/AWWA B300—Hypochlorites.
- ANSI/AWWA B301—Liquid Chlorine.
- ANSI/AWWA B604—Granular Activated Carbon.
- ANSI/AWWA C651—Disinfecting Water Mains.
- ANSI/AWWA C652—Disinfection of Water-Storage Facilities.
- ANSI/AWWA C655—Field Dechlorination.
- AWWA Manual M3—*Safety Practices for Water Utilities*.
- Chlorine Institute[†]—Chlorine Manual.
- Introduction to Water Treatment*. AWWA, Denver, Colo.
- Material Safety Data Sheets for forms of chlorine used (provided by suppliers).
- Standard Methods for the Examination of Water and Wastewater*. APHA,[‡] AWWA, and WEF,[§] Washington, D.C.
- Water Quality and Treatment*. Prepared by AWWA. McGraw-Hill Book Co., New York.

SECTION 3: DEFINITIONS

The following definitions shall apply in this standard:

^{*} American National Standards Institute, 25 West 43rd Street, Fourth Floor, New York, NY 10036.

[†] Chlorine Institute, 2001 I Street N.W., Suite 506, Washington, DC 20036.

[‡] American Public Health Association, 800 I Street NW, Washington, DC 20001.

[§] Water Environment Federation, 601 Wythe Street, Alexandria, VA 22314.

1. *Available chlorine:* A measure of the amount of chlorine in chlorinated lime, hypochlorite compounds, chloramines, and other materials that are used for disinfection compared with the amount in elemental (liquid or gaseous) chlorine.

2. *Chlorine, free:* Also called *free available chlorine*, the amount of chlorine available as dissolved gas (Cl_2), hypochlorous acid (HOCl), and hypochlorite (OCl^-) that is not combined with ammonia (NH_3) or other compounds in water that is available for disinfection.

3. *Chlorine residual:* Concentration of chlorine species present in water after the oxidant demand has been satisfied.

4. *Contractor:* The party that provides the work and materials for placement or installation.

5. *Disinfectant:* Any oxidant, including, but not limited to, chlorine, chlorine dioxide, chloramine, and ozone, that is added to water in any part of the treatment or distribution process and is intended to kill or inactivate pathogenic microorganisms. For the purposes of this standard, the disinfectants to be used are chlorine solutions derived from liquid chlorine, sodium hypochlorite, or calcium hypochlorite.

6. *Disinfection:* A process that inactivates pathogenic organisms in water by chemical oxidants or equivalent agents.

7. *Liquid chlorine:* The commercially available form of liquefied elemental chlorine gas as described in ANSI/AWWA B301. (The term *liquid chlorine* is sometimes used to describe a hypochlorite solution. This use of the term is discouraged. See ANSI/AWWA B300, Hypochlorites.)

8. *Purchaser:* The person, company, or organization that purchases any materials or work to be performed.

SECTION 4: REQUIREMENTS

Materials shall comply with the requirements of the Safe Drinking Water Act and other federal regulations for potable water, wastewater, and reclaimed water systems as applicable.

Sec. 4.1 Cleaning

The entire newly constructed treatment facility (including treatment units and piping not requiring disinfection under the provisions of this standard) shall be thoroughly cleaned before the new facility is disinfected and placed in service.

Existing treatment units and piping temporarily taken out of service for inspection, maintenance, repair, or any other activity or event that might lead to contamination of the process water shall be thoroughly cleaned before being disinfected and returned to service. Cleaning agents used shall not contain hazardous substances or deleterious compounds that would cause a violation of water quality health-effects standards if subsequently introduced into the water supply during disinfection and filling operations.

Scaffolding, planks, tools, rags, and any other material not part of the structural or operating facilities of the treatment unit shall be removed. Once the materials are removed, the surfaces of the walls, floors, and attached structures shall be thoroughly cleaned with a high-pressure water jet, or by sweeping, scrubbing, or other equally effective means. Water, paint flakes, sediment, dirt, and foreign material accumulated during this cleaning operation shall be discharged, vacuumed, or otherwise removed from the unit.

Sec. 4.2 Units Requiring Disinfection

Because of the variety of water treatment plants and the components and types of filtration media used, it is difficult to generalize disinfection of all treatment plants. However, the goals of the process are as follows: Disinfection is required for elements of the treatment plant that are in contact with disinfected water under normal plant operations. Some components may not be compatible with chlorine products (e.g., granular activated carbon [GAC], biologically active filters, some membranes, etc.); however, basins, clearwells, pump suction wells, pipes, and related appurtenances downstream of the point of disinfection during normal plant operations must be disinfected. For plants using filtration with gravel, silica, sand, anthracite, and other mixed media materials except GAC, disinfection of these areas is described in Sec. 4.4.3–4.4.4. For GAC, Sec. 4.4.4.3 applies. Areas of the plant not requiring disinfection, but which must be thoroughly cleaned as described in Sec. 4.1, include raw water inlets, chemical feed systems and components of the plant prior to the first point of disinfection, and areas not compatible with chlorine disinfection. It is recommended that equipment and storage facilities of chemical feed systems that inject downstream of the first point of application of process disinfection be cleaned and rinsed with disinfectant before being placed in service. It is recommended that a plan be developed identifying the areas of the plant to be disinfected before the start of the disinfection process.

Sec. 4.3 Materials for Disinfectant Chlorine Solutions

The forms of chlorine that may be used in the disinfecting operations are liquid chlorine as described in ANSI/AWWA B301, sodium hypochlorite solution as described in ANSI/AWWA B300, and calcium hypochlorite granules or tablets as described in ANSI/AWWA B300. Appropriate personal protective equipment should be worn when using these products.

4.3.1 *Liquid chlorine.* Liquid chlorine contains 100 percent available chlorine and is packaged in steel containers, usually of 100-lb, 150-lb, or 1-ton net chlorine weight. Liquid chlorine shall be used only (1) in combination with appropriate gas-flow chlorinators and injectors to provide a solution feed of controlled concentration to the water to be chlorinated; (2) under the direct supervision of a person who is familiar with chlorine's physiological, chemical, and physical properties, and who is trained and equipped to handle any emergency that may arise; and (3) when appropriate safety practices are observed to protect working personnel and the public.

4.3.2 *Sodium hypochlorite.* Sodium hypochlorite is available in solution form in glass, rubber-lined, or plastic containers typically ranging in size from 1 pt to 5 gal or in fifteen gallon carboys; containers of 30-gal or larger size may be available in some areas. Sodium hypochlorite contains approximately 5 percent to 15 percent available chlorine, when manufactured. The strength of the sodium hypochlorite solution will deteriorate, and chlorate and perchlorate will be formed over time. The rate of deterioration is strongly affected by storage conditions and the hypochlorite should be stored in a cool, dry, dark environment to minimize deterioration.

4.3.3 *Calcium hypochlorite.* Calcium hypochlorite is available in granular form or in small tablets and contains approximately 65 percent available chlorine by weight. The calcium hypochlorite should be stored in a cool, dry, dark environment to minimize its deterioration. The precautions listed on the container should be carefully noted. NOTE: Calcium hypochlorite may be difficult to dissolve in water with high calcium hardness (hardness in excess of 100 mg/L).

Sec. 4.4 Plant Disinfection Procedures

4.4.1 *Plant piping.* Plant process piping downstream of the filter or the first point of disinfection and pump stations shall be disinfected using one of three alternative methods described in ANSI/AWWA C651, including application methods, chlorine solution strengths, contact times, disposal of highly chlorinated water, and bacteriological sampling and testing.

4.4.2 *Tanks and clearwells.* Water storage tanks, clearwells, and similar receptacles shall be disinfected using one of the methods described in ANSI/AWWA C652, including application methods, chlorine solution strengths, contact times, disposal of highly chlorinated water, and bacteriological sampling and testing.

4.4.3 *Filters.* This section describes disinfection of filter basins and gravel, silica sand, anthracite, and other mixed media materials except granular activated carbon (GAC). GAC cannot feasibly be disinfected in the field. Therefore, when GAC is to be part of the filter media, special care shall be used to protect the GAC from contamination; all other media shall be placed in the filter basin and disinfected before placement of the GAC.

4.4.3.1 *Preparation.* Before any filter material is placed, the filter basin itself shall be thoroughly cleaned as described in Sec. 4.1.

4.4.3.2 *Media placement.* After the filter basin has been cleaned, the filter media shall be placed in the basin in accordance with ANSI/AWWA B100, using reasonable precautions to maintain cleanliness. Following placement, the filter media shall be backwashed and prepared for service in accordance with ANSI/AWWA B100.

4.4.4 *Filter disinfection.* After all other work is completed, and before the filter is placed in service, the entire filter basin up to the maximum water level shall be disinfected by one of the following methods.

4.4.4.1 *Disinfection procedure.* Sufficient chlorine shall be injected into the backwash water to produce a free chlorine residual of at least 25 mg/L throughout the filter. The chlorinated water shall be allowed to stand in the filter for at least 12 hr. At the end of the 12-hr contact time, the chlorinated water shall be tested to determine the amount of free chlorine residual. If the free residual is less than 15 mg/L, the chlorination process shall be repeated. Sufficient tests should be made both from the top and bottom of the unit (and at intermediate points if feasible) to ensure the residual readings measure the lowest chlorine level existing in the unit at the end of the 12-hr contact period. If satisfactory chlorine residuals are obtained after the chlorine contact period, the filter shall be run to waste or backwashed thoroughly to remove the highly chlorinated water.

4.4.4.2 *Alternative procedure.* Sufficient chlorine shall be continuously injected into the filter influent water while filtering to waste to produce a free residual of at least 25 mg/L. When water with at least a 25 mg/L free residual chlorine concentration reaches the filter-to-waste, the flow of water shall be stopped,

and the filter shall be held full of the chlorinated water for a period of not less than 12 hr. At the end of the 12-hr contact time, the chlorinated water shall be tested to determine the free residual. If the free residual is less than 15 mg/L, the chlorination process shall be repeated. Sufficient tests should be made both from the top and bottom of the unit (and at intermediate points if feasible) to ensure the residual readings measure the lowest chlorine level existing in the unit at the end of the 12-hr contact period. After the chlorine contact period, if satisfactory chlorine residuals are obtained, the filter shall be run to waste or backwashed thoroughly to remove the highly chlorinated water.

4.4.4.3 GAC filters. Disinfection of GAC (see ANSI/AWWA B604) gravity filters shall be similar to Sec. 4.4.3.1, 4.4.3.2, 4.4.4.1, and 4.4.4.2 except that in Sec. 4.4.3.2, all media and support gravel (see ANSI/AWWA B100) except GAC shall be placed in the filter prior to disinfection. Following disinfection according to Sec. 4.4.4.1 or 4.4.4.2, the GAC may be placed in the filter. The GAC must be stored and handled to avoid any contamination. Any equipment used in placing the GAC in the filter must be cleaned and disinfected with a 200 mg/L solution of free residual chlorine immediately before use. This includes shovels, spreading devices, or other equipment that comes in contact with the GAC. In addition, workers shall wear rubber boots and gloves that have been previously disinfected with a 200-mg/L free residual chlorine solution if coming in contact with the carbon or entering the filter. Disinfection of GAC pressure filter vessels shall follow Sec 4.4.2 before placement of GAC media.

4.4.4.4 Chlorinated discharge. If there is any question that the chlorinated discharge will cause damage to the environment, a reducing agent shall be applied to the water to neutralize the residual chlorine. Federal, state or provincial, and local environmental regulations may require special provisions or permits before disposal of highly chlorinated water. Refer to ANSI/AWWA C655 Field Dechlorination for appropriate dechlorination requirements.

SECTION 5: VERIFICATION

Sec. 5.1 Bacteriological Sampling

After the disinfection procedure is completed, and before the treatment unit or facility is placed in service, two or more samples shall be taken from the unit or facility not less than 30 min apart and shall be tested for the presence of total coliform

bacteria in accordance with Section 9221, 9222, or 9223 of the *Standard Methods for the Examination of Water and Wastewater*. If none of the samples show the presence of total coliform bacteria, the unit or facility may be placed in service.

If any of the samples show the presence of total coliform bacteria, one of the following procedures shall be followed before placing the unit or facility in service.

1. Take repeat samples at least 24 hr apart until consecutive samples do not show the presence of total coliform bacteria.

2. Chlorinate the unit or facility in accordance with Sec. 4.4.4. and resample.

If a disinfected facility is not immediately returned to service, any delay should be evaluated to determine if the water quality may have been adversely affected and additional testing warranted. Test results should confirm the water quality is appropriate for distribution. Although this assessment is unique for each system, suggested parameters considered for testing include disinfectant residual, total coliform bacteria, turbidity, pH, alkalinity, odor, and specific conductance.

Sec. 5.2 Record of Compliance

The report of bacteriological test results certifying that the water discharged from the treatment facility is free of total coliform bacteria shall serve as the record of compliance.

SECTION 6: DELIVERY

This standard has no applicable information for this section.

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