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AWWA Standard

Disinfecting Water Mains

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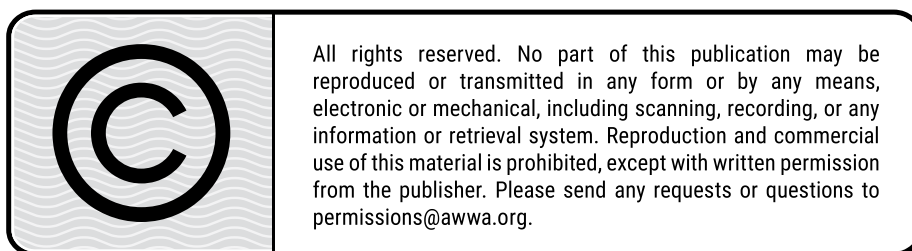
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Committee Personnel

The AWWA Standards Subcommittee on Disinfecting Water Mains, which developed revisions to this standard, had the following personnel at the time:

Victor Galvez, *Chair*

K. Billedo, Los Angeles Department of Water and Power, Los Angeles, Calif.
P.J. Freeman, City of Fort Smith, Fort Smith, Ark.
V. Galvez, Metropolitan Water District of Southern California, La Verne, Calif.
J.M. Henderson, Consultant, West Linn, Ore.
R.C. Lorenz, Westerville Water Plant, Westerville, Ohio
M. Martinez, Los Angeles Department of Water and Power, Los Angeles, Calif.
D.M. O'Connor, EPA Region 3, Philadelphia, Pa.
B. Reilley, Massachusetts Water Resources Authority, Boston, Mass.
J.R. Rhoads, Metropolitan Water District of Southern California, Granada Hills, Calif.
T.J. Trocha, Miles & Miles of Texas, Buda, Tex.

The AWWA Standards Committee on Disinfection of Facilities, which reviewed and approved this standard, had the following personnel at the time of approval:

Gerald J.R. Rhoads, *Chair*

Timothy J. Trocha, *Vice Chair*

General Interest Members

K.C. Choquette, Choquette Engineering, Des Moines, Iowa
A. Dail (*liaison, nonvoting*), Standards Engineer, AWWA, Denver, Colo.
J.M. Henderson, Consultant, West Linn, Ore.
D.M. O'Connor, EPA Region 3, Philadelphia, Pa.
A.A. Rosenblatt, Gordon & Rosenblatt LLC, New York, N.Y.
G.R. Stein (*liaison, nonvoting*), Standards Council Liaison, Tank Industry Consultants, Indianapolis, Ind.
S. Vidika, Dixon Engineering Inc., Medina, Ohio
M.A. Waer, GHD, Phoenix, Ariz.
J.S. Wailes, Consultant, Grand Junction, Colo.
M.L. Wentink, Nebraska Department of Environment and Energy, North Platte, Neb.

Producer Members

M.P. Parker, Statewide Aquastore Inc., East Syracuse, N.Y.

P.L. Smith, Smith LaSalle Inc., Western Springs, Ill.

T.J. Trocha, Miles & Miles of Texas, Buda, Tex.

User Members

K. Billedo, Los Angeles Department of Water and Power, Los Angeles, Calif.

Z. Bukhari, American Water, Camden, N.J.

M. Crawford, Bristol County Water Authority, Warren, R.I.

M. Daneshparvar, City of Dallas Water Utilities, Dallas, Tex.

P.J. Freeman, City of Fort Smith, Fort Smith, Ark.

R.C. Lorenz, Westerville Water Plant, Westerville, Ohio

J. Nilson, Seattle Public Utilities, Seattle, Wash.

B. Reilley, Massachusetts Water Resources Authority, Boston, Mass.

J.R. Rhoads, Metropolitan Water District of Southern California, Granada Hills, Calif.

E.D. Schwartz (*alternate*), New Jersey American Water Company, Plainsboro, N.J.

A. Waldron, City of Englewood, Englewood, Colo.

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Foreword

This foreword is for information only and is not a part of ANSI/AWWA C651.

I. Introduction.

I.A. *Background.* This standard describes methods of disinfecting newly constructed potable water mains; mains that have been removed from service for planned repairs or for maintenance that exposes them to contamination; mains that have undergone emergency repairs because of physical failure; and mains that continue to show the presence of coliform organisms under normal operation. The disinfecting agents discussed in this standard are chlorine solutions that may be derived from liquid chlorine (Cl_2), calcium hypochlorite [$\text{Ca}(\text{OCl})_2$], or sodium hypochlorite (NaOCl). Combinations of free chlorine residual and contact time are provided. Chlorine dosage reference tables are provided as Appendix B of this standard. Disinfecting water mains is necessary to ensure the protection of public health.

I.B. *History.* This standard was first approved on September 30, 1947, by the AWWA Board of Directors and published as 7D.2-1948, A Procedure for Disinfecting Water Mains. Revisions were approved on September 14, 1948; March 6, 1953; May 27, 1954; June 2, 1968; and June 7, 1981. All were done under the designation ANSI/AWWA C601, Standard for Disinfecting Water Mains. In 1986, the designation of the standard was changed to ANSI/AWWA C651, and the subsequent editions were approved on January 26, 1986; June 18, 1992; June 20, 1999; January 16, 2005; and June 8, 2014. This edition was approved on October 23, 2023.

I.C. *Acceptance.* In May 1985, the US Environmental Protection Agency (USEPA) entered into a cooperative agreement with a consortium led by NSF International (NSF) to develop voluntary third-party consensus standards and a certification program for direct and indirect drinking water additives. Other members of the original consortium included the Water Research Foundation (WRF, formerly AwwaRF) and the Conference of State Health and Environmental Managers (COSHEM). AWWA, and the Association of State Drinking Water Administrators (ASDWA), joined later.

In the United States, authority to regulate products for use in or in contact with drinking water rests with individual states.[†] Local agencies may choose to impose requirements more stringent than those required by the state. To evaluate the health

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

[†] Persons outside the United States should contact the appropriate authority having jurisdiction.

effects of products and drinking water additives from such products, state and local agencies may use various references, including

1. Specific policies of the state or local agency.
2. Four standards developed under the direction of NSF:[‡] NSF/ANSI/CAN[§] 60, Drinking Water Treatment Chemicals—Health Effects; NSF/ANSI/CAN 61, Drinking Water System Components—Health Effects; NSF/ANSI/CAN 372, Drinking Water System Components—Lead Content; and NSF/ANSI/CAN 600, Health Effects Evaluation and Criteria for Chemicals in Drinking Water.
3. Other references, including AWWA standards, *Food Chemicals Codex*, *Water Chemicals Codex*,[¶] and other standards considered appropriate by the state or local agency.

Various certification organizations may be involved in certifying products in accordance with NSF/ANSI/CAN 60. Individual states or local agencies have authority to accept or accredit certification organizations within their jurisdictions. Accreditation of certification organizations may vary from jurisdiction to jurisdiction.

NSF/ANSI/CAN 600 (which formerly appeared in NSF/ANSI/CAN 60 and NSF/ANSI/CAN 61 as Annex A, “Toxicology Review and Evaluation Procedures”) does not stipulate a maximum allowable level (MAL) of a contaminant for substances not regulated by a USEPA final maximum contaminant level (MCL). The MALs of an unspecified list of “unregulated contaminants” are based on toxicity testing guidelines (noncarcinogens) and risk characterization methodology (carcinogens). Use of NSF/ANSI/CAN 600 procedures may not always be identical, depending on the certifier.

ANSI/AWWA C651 does not address additives requirements. Thus, users of this standard should consult the appropriate state or local agency having jurisdiction in order to

1. Determine additives requirements including applicable standards.
2. Determine the status of certifications by parties offering to certify products for contact with, or treatment of, drinking water.
3. Determine current information on product certification.

[‡] NSF International, 789 North Dixboro Road, Ann Arbor, MI 48105.

[§] Standards Council of Canada, 55 Metcalfe Street, Suite 600, Ottawa, ON K1P 6L5 Canada.

[¶] Both publications available from National Academy of Sciences, 500 Fifth Street NW, Washington, DC 20001.

II. Special Issues.

II.A. *Information on Application of This Standard.* Generally, it is easier to disinfect a new main than one that has had emergency repairs in terms of access, sanitary control, and the time available for disinfection, sampling, and testing.

For a new main, there is typically more time available for disinfection and testing since there is no immediate demand from customers. Given the often significant amount of time and materials involved in a new water main project, careful disinfection and testing of the main are reasonable and necessary to ensure public health protection.

Conditions for pipe repair projects vary tremendously in terms of the size of the repair, the sanitary conditions, and the time constraints resulting from immediate customer demands. It should be noted if the line is depressurized or opened to the environment before or during repair, the sanitary integrity of the pipe is compromised. It is therefore critical to follow sanitary procedures throughout the repair and not just as it is being returned to service. Crews responsible for the repair of mains should be aware of the potential health hazards and trained to carefully observe prescribed construction practices and disinfection procedures.

Because of the differences between initial installation and repair, the disinfection requirements for each situation are also different. The installation of new mains requires that two sets of samples for coliform analysis are collected at least 16 h apart, or two sets collected 15 min apart after at least a 16-h rest period. For repaired mains that are depressurized and/or wholly or partially dewatered, one set of samples may be required, and depending on the sanitary conditions, the line may be returned to service before the completion of bacteriological testing. For repaired mains that are kept under positive pressure at all times, bacteriological testing is not required.

In contrast to past requirements, samples must now be collected at least 16 h apart or 15 min apart after a 16-h rest period. This revised method is protective of public health while taking into consideration improved test methods and timely work completion. The timing is sufficient to allow bacterial regrowth within the line if there is contamination and provides more flexibility in the scheduling of various work activities.

Bacteriological testing in accordance with Sec. 6.1 is used to verify the absence of coliform organisms and is generally accepted as verification that disinfection of the pipeline has been successfully accomplished. The use of sanitary practices for handling and installing pipe, valves, fittings, and accessories, coupled with adequate flushing of the line before disinfection, is necessary to ensure that the disinfected pipeline will be ready for connection to the water system. If a pipeline fails the bacteriological test,

the flushing or disinfection process must be repeated. The final water quality test is not the primary means for certifying the sanitary condition of a main. The sanitary handling of materials, the practices during construction, and the continual inspection of the work are the primary means for ensuring the sanitary condition of the water main. For additional information on preventing microbiological contamination of water mains, refer to WRF's Field Pocket Guide *Good Practices for Preventing Microbial Contamination of Water Mains*.

Four methods of disinfecting newly constructed water mains are described in this standard: the tablet method, the continuous-feed method, the slug method, and the spray method. The utility should decide which of these methods is most suitable for a given situation. Factors to consider when choosing a method should include the length and diameter of the main, type of joints present, availability of materials, equipment required for disinfection, training of the personnel who will perform the disinfection, and safety concerns. For example, if gas chlorination is the chosen chemical when either continuous-feed or slug methods are being used, use only properly designed and constructed equipment; makeshift equipment is not acceptable when liquid chlorine (gas) cylinders are used.

Thorough consideration should be given to the impact of highly chlorinated water flushed into the environment. If there is any question that damage may be caused by chlorinated-waste discharge (to fish life, plant life, physical installations, or other downstream water uses of any type), then an adequate amount of reducing agent should be applied to water being disposed of in order to thoroughly neutralize the chlorine residual remaining in the water. ANSI/AWWA C655 provides the minimum requirements and guidance for the dechlorination of chlorinated or chloraminated water being discharged, including regulatory issues.

The tablet method cannot be used unless the main can be kept clean and dry. The tablet method should not be considered if pre-flushing or hydrostatic testing of the main will be performed before chlorination. However, the method can be considered if hydrostatic testing will be performed concurrent with chlorination. This method cannot be used in large-diameter mains if it is necessary for a worker to enter the main to grout joints or perform inspection because the tablets may release toxic fumes after exposure to moist air. Calcium hypochlorite tablets/granules must not be used to disinfect HDPE piping systems. When using the tablet method, the chlorine concentration is not uniform throughout the main because the hypochlorite solution is dense and tends to concentrate at the bottom of the pipe. The use of the tablet method precludes preliminary flushing. The tablet method is convenient to use in mains having

diameters up to 24 in. (600 mm), and it requires no special equipment. Failure to meet the required minimum residual after 24- or 48-h hold or failure to obtain satisfactory bacteriological sample results after application of the tablet method will require the user to switch to another available method that does not require a dry main before chlorination. This method cannot be repeated for the same main after failure.

The continuous-feed method is suitable for general application. Preliminary flushing removes light particulates from the main but not from the pipe-joint spaces. The chlorine concentration is uniform throughout the main.

The slug method is suitable for use in large-diameter mains where the volume of water makes the continuous-feed method impractical and difficult to achieve for short attachments. The slug method results in appreciable savings of chemicals used to disinfect long large-diameter mains. Also, this method reduces the volume of heavily chlorinated water to be flushed to waste.

The spray method is suitable for use in large-diameter transmission lines where spray equipment can be used to disinfect all surfaces of the pipe. This method reduces the volume of heavily chlorinated water to be flushed to waste.

The purpose of all four chlorination methods is to disinfect water lines, resulting in an absence of coliforms as confirmed by laboratory analysis. As noted above, the four methods attempt to provide flexibility in responding to specific situations. The tablet and continuous-feed methods both require an initial free chlorine dose of 25 mg/L and a minimum contact time of 24 h. The tablet method cannot be flushed and cleaned before disinfection, whereas the continuous-feed or slug method can be used when hydrostatic testing and flushing are being performed before chlorination. Both methods require a remaining free chlorine residual of 10 mg/L after at least 24 h. To meet the needs of situations requiring reduced contact times, the slug method allows only a 3-h contact time but requires a 100-mg/L initial free chlorine concentration. For larger transmission lines, spray disinfection using a free chlorine solution with a concentration of 200 mg/L may be a suitable option, minimizing discharges of highly chlorinated water. While the contact times of the methods may not be identical, the end result—absence of coliforms—is the same for all four methods. Additionally, care must be taken not to excessively chlorinate above the recommended levels as overchlorination may lead to potential exposure at high levels and may negatively impact the integrity of the water line and associated appurtenances.

Disinfectants other than chlorine may be appropriate to use. Although this standard describes only the use of liquid chlorine (gas), 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.* This standard is written as though the disinfection work will be performed by the purchaser's personnel. The water purveyor is the purchaser in most cases. Where the work is to be performed using a separate contract or as part of a contract for installing mains,* appropriate provisions should be included in the purchase documents to ensure that the constructor is specifically instructed as to its responsibilities. The following information should be provided by the purchaser.

1. Standard used—that is, ANSI/AWWA C651, Disinfection of Water Mains, of latest revision.
2. Approval requirements before use.
3. Those procedures included in the standard designated as optional that are to be included in the purchase documents.
4. Whether compliance with NSF/ANSI/CAN 60, Drinking Water Treatment Chemicals—Health Effects, is required.
5. Whether compliance with NSF/ANSI/CAN 61, Drinking Water System Components—Health Effects, is required.
6. Details of federal, state, provincial, territorial, and local requirements (Sec. 4).
7. Form of chlorine to be used (Sec. 4.1.1, Sec. 4.1.2, and Sec. 4.1.3).
8. Method of chlorination (Sec. 4.3, Sec. 4.4, Sec. 4.5, and Sec. 4.6).
9. Flushing locations, rates of flushing, and locations of drainage facilities (Sec. 4.4.2, Sec. 5.3.1, and Sec. 5.3.2).
10. Responsibility for tapping existing mains and connections to new mains (Sec. 4.4.3[1], Sec. 4.4.3[2], and Sec. 5.4).
11. The number and frequency of samples for bacteriological tests (Sec. 6.1.1, Sec. 6.1.2, and Sec. 6.2).
12. Method of taking samples (Sec. 6.1.3).

* Refer to other AWWA standards and manuals for design criteria and installation procedures for various pipe materials.

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 revisions made to the standard in this edition include the following:

1. The scope of the standard has been modified to include water mains used for temporary service when replacing or repairing existing water mains (Sec. 1.1).
2. Definitions for potable water, reclaimed water, and wastewater have been added (Sec. 3).
3. A requirement for disinfection chemical compliance with NSF/ANSI/CAN 60 has been added (Sec. 4.1).
4. General considerations for the four methods of chlorination have been expanded (Sec. 4.2).
5. The provisions for executing the four methods of chlorination have been expanded (Sec. 4.3, Sec. 4.4, Sec. 4.5, and Sec. 4.6).
6. The Sec. 4 subsections on disinfection procedures (Sec. 4.7, Sec. 4.8, Sec. 4.9, Sec. 4.10, and Sec. 4.11) have been relocated to a new Sec. 5 on Procedures and renumbered as Sec. 5.1, Sec. 5.2, Sec. 5.3, Sec. 5.4, and Sec. 5.5, respectively. Sec. 5 and Sec. 6 have been renumbered accordingly as Sec. 6 and Sec. 7, respectively.
7. Additional guidance on backflow prevention as a method of reducing risk from high chlorine levels and microbial contamination has been provided (Sec. 5.2.9).
8. A new section on Inspection of Large Diameter Pipes Without Repair Work has been added (Sec. 5.5.5).
9. A new appendix section on DPD Reagent Pillows Method No. 2 (for Field Test) has been added (Sec. A.2).
10. The appendix section on High-Range Chlorine Test Kits has been expanded (Sec. A.3).
11. Table B.1 and Table B.2 in Appendix B on Chlorine Dosages have been modified.

V. Comments. If you have any comments or questions about this standard, please call the AWWA Engineering and Technical Services at 303.794.7711; 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 C651-23
(Revision of ANSI/AWWA C651-14)

AWWA Standard

Disinfecting Water Mains

SECTION 1: GENERAL

Sec. 1.1 Scope

This standard describes essential procedures for the disinfection of new and repaired potable water mains, including water mains used for temporary service when replacing or repairing existing water mains. New or temporary water mains shall be disinfected before they are placed in service. Water mains taken out of service for inspection, repair, or other activities may or may not require disinfection and sampling, depending on the risk of contamination and/or the duration of inactive service. This standard describes the process for evaluating the risk under different conditions. This standard is meant to be used for water mains within public water systems and is not intended for premise plumbing systems in buildings. Premise plumbing components in buildings use a wide variety of materials, including some that may not be compatible with the chlorine concentrations in this standard.

Sec. 1.2 Purpose

The purpose of this standard is to define the minimum disinfection, sampling, and handling requirements when installing new mains or repairing a main break. These requirements identify when disinfection is required based on the level of public health risk. Included in this standard are requirements for disinfection of water mains, preparation and sanitary handling of water mains, application of