



Return to Main Menu



Return to List of Standards



Return to History of Standards



American Water Works Association

Dedicated to the World's Most Important Resource®

ANSI/AWWA D104-17
(Revision of ANSI/AWWA D104-11)

AWWA Standard

Automatically Controlled, Impressed-Current Cathodic Protection for the Interior Submerged Surfaces of Steel Water Storage Tanks

Effective date: Dec. 1, 2017.

First edition approved by AWWA Board of Directors Jan. 27, 1991.

This edition approved June 11, 2017.

Approved by American National Standards Institute Aug. 3, 2017.



AWWA Standards have been used with permission and are copyrighted to the American Water Works Association. All rights reserved.

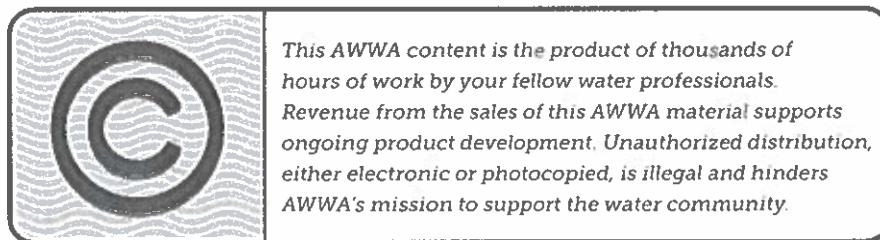
AWWA Standard

This document is an American Water Works Association (AWWA) standard. It is not a specification. AWWA standards describe minimum requirements and do not contain all of the engineering and administrative information normally contained in specifications. The AWWA standards usually contain options that must be evaluated by the user of the standard. Until each optional feature is specified by the user, the product or service is not fully defined. AWWA publication of a standard does not constitute endorsement of any product or product type, nor does AWWA test, certify, or approve any product. The use of AWWA standards is entirely voluntary. This standard does not supersede or take precedence over or displace any applicable law, regulation, or code of any governmental authority. AWWA standards are intended to represent a consensus of the water industry that the product described will provide satisfactory service. When AWWA revises or withdraws this standard, an official notice of action will be placed on the first page of the Official Notice section of *Journal – American Water Works Association*. The action becomes effective on the first day of the month following the month of *Journal – American Water Works Association* publication of the official notice.

American National Standard

An American National Standard implies a consensus of those substantially concerned with its scope and provisions. An American National Standard is intended as a guide to aid the manufacturer, the consumer, and the general public. The existence of an American National Standard does not in any respect preclude anyone, whether that person has approved the standard or not, from manufacturing, marketing, purchasing, or using products, processes, or procedures not conforming to the standard. American National Standards are subject to periodic review, and users are cautioned to obtain the latest editions. Producers of goods made in conformity with an American National Standard are encouraged to state on their own responsibility in advertising and promotional materials or on tags or labels that the goods are produced in conformity with particular American National Standards.

CAUTION NOTICE: The American National Standards Institute (ANSI) approval date on the front cover of this standard indicates completion of the ANSI approval process. This American National Standard may be revised or withdrawn at any time. ANSI procedures require that action be taken to reaffirm, revise, or withdraw this standard no later than five years from the date of publication. Purchasers of American National Standards may receive current information on all standards by calling or writing the American National Standards Institute, 25 West 43rd Street, Fourth Floor, New York, NY 10036; 212.642.4900; or emailing info@ansi.org.



ISBN-13, print: 978-1-62576-274-0

eISBN-13, electronic: 978-1-61300-458-6

DOI:<http://dx.doi.org/10.12999/AWWA.D104.17>

All rights reserved. No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopy, recording, or any information or retrieval system, except in the form of brief excerpts or quotations for review purposes, without the written permission of the publisher.

Copyright © 2017 by American Water Works Association
Printed in USA

Committee Personnel

The AWWA Cathodic Protection Task Force, which developed this standard, had the following personnel at the time:

David H. Kroon, *Chair*

C.W. Dessens, City of Houston, Houston, Texas	(AWWA)
R.A. Gummow, Correng Consulting Services, Downsview, Ont., Canada	(AWWA)
T.D. Hopper, Tank Connection Affiliate Group, Lindale, Texas	(AWWA)
C.C. Johnson, Corrpro Companies Inc., San Diego, Calif.	(AWWA)
R.J. Kochilla, City of Cleveland, Parma, Ohio	(AWWA)
D.H. Kroon, Aegion Corporation, Houston, Texas	(AWWA)
L.D. Scott, Paso Robles Tank—Brown-Minneapolis Tank Inc., Paso Robles, Calif.	(AWWA)
G.R. Stein, Tank Industry Consultants, Indianapolis, Ind.	(AWWA)
J.J. Sweeney, CST Storage, Dekalb, Ill.	(AWWA)

The Standards Committee on Steel and Composite Water Storage Tanks, which reviewed and approved this standard, had the following personnel at the time of approval:

Stephen W. Meier, *Chair*

Gregory R. Stein, *Vice-Chair*

User Members

J. Camarena, East Bay Municipal Utility District, Oakland, Calif.	(AWWA)
T.M. Dawson Jr., Emerald Coast Utilities Authority, Pensacola, Fla.	(AWWA)
M.F. Gaffey, Naval Facilities Expeditionary Warfare Center, Washington Navy Yard, D.C.	(AWWA)
R.E. McCuller, City of Grand Prairie, Grand Prairie, Texas	(AWWA)
N.J. Meder, Connecticut Water Company, Clinton, Conn.	(AWWA)
J.L. Ortiz, San Francisco Public Utilities Commission, San Francisco, Calif.	(AWWA)
R.B. Potts, Louisville Water Company, Louisville, Ky.	(AWWA)
G. Terrell, Birmingham Water Works Board, Birmingham, Ala.	(AWWA)

General Interest Members

D.M. Algranti, Albert A. Webb Associates, Riverside, Calif.	(AWWA)
J.W. Birkhoff, Birkhoff, Hendricks & Carter LLP, Dallas, Texas	(AWWA)

J.D. Brock, Consulting Services Logistics, Toledo, Ohio	(AWWA)
M.M. Coleman,* Standards Council Liaison, Wade Trim Associates Inc., Detroit, Mich.	(AWWA)
E. Darrimon, Bay Area Coating Consultants Inc., Denair, Calif.	(AWWA)
W.J. Dixon, Dixon Engineering Inc., Lake Odessa, Mich.	(AWWA)
R.E. Gell, O'Brien & Gere Engineers, Syracuse, N.Y.	(AWWA)
M.L. Hickey, Murray, Smith & Associates Inc., Portland, Ore.	(AWWA)
F.S. Kurtz,* Standards Engineer Liaison, AWWA, Denver, Colo.	(AWWA)
S.W. Meier, Tank Industry Consultants, Indianapolis, Ind.	(AWWA)
R.L. Moore, St. Louis, Mo.	(AWWA)
G.R. Stein,† Tank Industry Consultants, Indianapolis, Ind.	(AWWA)
J.I. Strand, CBS Squared Inc., Chippewa Falls, Wis.	(AWWA)
T.A. Tovey, CH2M, Portland, Wash.	(AWWA)

Producer Members

G.A. Burke, Caldwell Tanks Inc., Louisville, Ky.	(AWWA)
W.J. Czaska, CB&I, Plainfield, Ill.	(AWWA)
J.W. Davis, Tesla NanoCoatings Inc., Massillon, Ohio	(AWWA)
K.T. Fuller, Phoenix Fabricators & Erectors LLC, Avon, Ind.	(AWWA)
J. Grendzinski,† Landmark Structures, Wheaton, Ill.	(AWWA)
B.E. Kromer, Tank Builders Inc., Euless, Texas	(AWWA)
K. McGuire, CST Storage, Parsons, Kan.	(AWWA)
R. Pawski, Landmark Structures, Wheaton, Ill.	(AWWA)
L.D. Scott, Paso Robles Tank—Brown-Minneapolis Tank Inc., Paso Robles, Calif.	(AWWA)

* Liaison, nonvoting

† Alternate

Contents

All AWWA standards follow the general format indicated subsequently. Some variations from this format may be found in a particular standard.

SEC.	PAGE	SEC.	PAGE
<i>Foreword</i>		3	Definitions 2
I	Introduction vii	4	Requirements
I.A	Background vii	4.1	Design 5
I.B	History vii	4.2	System Components 7
I.C	Acceptance vii	4.3	Installation 9
II	Special Issues viii	5	Verification
II.A	Protective Coatings viii	5.1	Inspection and Handling 10
II.B	Cathodic Protection ix	5.2	Testing 10
III	Use of This Standard xi	5.3	Operation and Maintenance Manual 11
III.A	Purchaser Options and Alternatives xi	<i>Appendixes</i>	
III.B	Modification to Standard xiv	A	Commentary and Additional Information 13
IV	Major Revisions xiv	B	Operation Guidelines for Cathodic Protection Systems 17
V	Comments xiv	C	Service and Maintenance of Impressed-Current Cathodic Protection Systems 19
<i>Standard</i>			
1	General		
1.1	Scope 1		
1.2	Purpose 1		
1.3	Application 2		
2	References 2		

This page intentionally blank.

Foreword

This foreword is for information only and is not a part of ANSI/AWWA D104.

I. Introduction.

I.A. *Background.* This standard describes automatically controlled, impressed-current cathodic protection systems for the interior submerged surfaces of steel water storage tanks. This standard does not cover sacrificial (galvanic) anode-type cathodic protection systems (see ANSI/AWWA D106) or manually controlled rectifiers.

I.B. *History.* Before the development of ANSI/AWWA D104, cathodic protection equipment was covered in ANSI/AWWA D102, Painting and Repainting Steel Tanks, Standpipes, Reservoirs, and Elevated Tanks for Water Storage. ANSI/AWWA D102-64 addressed cathodic protection equipment in Section 4. In the 1978 edition of that standard, however, the provisions for cathodic protection equipment were removed, and the development of a new AWWA standard on cathodic protection was needed. This standard became ANSI/AWWA D104, Automatically Controlled, Impressed-Current Cathodic Protection for the Interior of Steel Water Tanks. The first edition of ANSI/AWWA D104 was approved by the AWWA Board of Directors on Jan. 27, 1991. Subsequent editions were approved on Feb. 2, 1997; June 17, 2001; June 13, 2004; and Jan. 23, 2011. This edition of the standard was approved on June 11, 2017.

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 (formerly AwwaRF) and the Conference of State Health and Environmental Managers (COSHEM). The American Water Works Association (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 effects of products and drinking water additives from such products, state and local agencies may use various references, including

[^] 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.

1. Specific policies of the state or local agency.
2. Two standards developed under the direction of NSF^{*}: NSF/ANSI 60 Drinking Water Treatment Chemicals—Health Effects, and NSF/ANSI 61 Drinking Water System Components—Health Effects.
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 61. 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.

Annex A, “Toxicology Review and Evaluation Procedures,” to NSF/ANSI 61 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 Annex A procedures may not always be identical, depending on the certifier.

ANSI/AWWA D104 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.

II. Special Issues.

II.A. *Protective Coatings.* Protective coatings are commonly used in steel water storage tanks. They are an effective method of corrosion control except where holidays exist in the coating caused by poor surface preparation, improper application, defective materials, unanticipated conditions, deterioration over time, or damage. When properly designed and maintained, cathodic protection systems will mitigate corrosion at the submerged locations where there are coating holidays or other coating defects. A properly applied coating reduces the surface area of bare steel in contact with the drinking water that requires cathodic protection, and reduces the amount of

^{*} NSF International, 789 North Dixboro Road, Ann Arbor, MI 48105.

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

current required to cathodically protect the tank interior submerged surface. Use and maintenance of protective coatings extend the life of the cathodic protection system and reduce operating costs. For submerged areas of a tank, cathodic protection can also reduce the frequency of coating maintenance. Cathodic protection or coatings can independently reduce corrosion on the interior submerged surfaces; however, the combination of coatings and cathodic protection may be more economical and effective than using coatings or cathodic protection alone.

II.B. *Cathodic Protection.* The two major components of an automatically controlled, impressed-current cathodic protection system are the direct current (DC) power supply controller (rectifier) and the anode system. The range of output current capacity required for an automatically controlled rectifier in a specific application is determined by assuming the area of submerged bare steel to be protected when the interior tank coating is new and when the interior coating has deteriorated to the point at which recoating is necessary. In potable water, current density requirements can range from 0.5 to 5.0 mA/ft² (5.4 to 53.8 mA/m²) of bare steel surface. Applications involving turbulence, high temperature, or a combination of these may require higher current densities. For newly coated tanks, the total current requirement may be as little as 1 percent of the current required to protect an uncoated surface. As a rule, rectifiers for newly coated tanks should have sufficient current capacity to protect the anticipated bare submerged surface area before coating repair or replacement. The required operating voltage of a rectifier for a specific tank depends on the current required to provide adequate protection and the total circuit resistance of the system.

Automatically controlled rectifier systems should be used for cathodic protection of water storage tanks when AC power is available to the tank site. Automatically controlled systems use one or more long-life reference electrodes to monitor the protection levels maintained on the submerged surfaces. The rectifier controller continuously monitors the potential difference between the reference electrode and the tank's submerged surface, referred to as the *tank-to-water potential*, which will be free of IR (current × resistance, or voltage) drop error. IR drop must be eliminated or minimized to accurately determine if the voltage difference between the submerged surface of the tank and the reference electrode meets the criteria for cathodic protection. The controller instantaneously interrupts the flow of cathodic protection current, providing an IR drop-free measurement, which closely approximates the polarized potential. The controller compares the measured tank-to-water potential to a preset value and automatically adjusts the voltage output of the rectifier, to either increase or decrease current accordingly. Automatic units include a tank-to-water potential monitoring meter, which can be easily checked by the purchaser.

NOTE: Manually controlled rectifiers are not recommended for use in water storage tanks and are not covered by this standard. The reason for this is that they require frequent monitoring, testing, and manual adjustment of the rectifier current output whenever the current requirements change because of changes in water level, coating condition, temperature, water chemistry, water turbulence, or accumulation of polarization films. Failure to adjust the current output for manual rectifiers can result in corrosion caused by underprotection or coating damage caused by overprotection.

The second major component of an automatically controlled system is the anode system. The anode system includes the anode material and the method of suspending the anode within the tank. The type of anode material and suspension system used is typically based on the tank's susceptibility to icing conditions.

For tanks subject to icing conditions, a seasonal or a long-life anode system may be used. A seasonal (or temporary) arrangement consists of vertically suspended anodes. This type of suspension system is susceptible to ice damage. Ice will adhere to some portion of the anode string and tear the anodes loose, causing the system to fail. Because it is anticipated that the anodes will be damaged annually, low-cost aluminum rod anodes are used. While the anode system is intact, the system will operate properly during the more corrosive summer season. In locations subject to freezing temperatures, there is usually a 2- to 5-month period during the winter when the system may not operate properly because of ice damage. This type of anode system will usually require annual replacement of the anodes and vertical anode suspension system. Anode remnants should be removed from the tank whenever the interior is accessible.

A long-life anode system includes suspension systems that are designed to be more resistant to ice damage and permit the use of long-life anode materials that have a design life of at least 10 years. The potential for ice damage is reduced by attaching the anode material to a buoyant or horizontally submerged radial rope system that is attached to the walls of the tank and prevents the anode system from coming in contact with ice formations. Another type of system compensates for ice damage by attaching the anode material to an extendable element suspended from the tank roof. The extendable element stretches with the movement of ice and allows the anode to eventually return to its original position.

For tanks not subject to icing conditions, anodes may be suspended from the tank roof without an extendable element or may be horizontally supported from a submerged radial rope system.

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.

Contractual responsibilities for items such as design, material, fabrication, construction, inspection, testing, and operation have been removed from the standard and must be addressed in the contract documents.

Many tanks using automatically controlled, impressed-current cathodic protection systems for interior submerged surfaces* have been in service for more than 30 years. Proper design and maintenance of impressed-current cathodic protection systems can help steel water storage tanks achieve an almost unlimited service life.

This standard does not cover systems where the purchaser specifies criteria for protection other than those listed in this standard. This standard does not cover systems to be installed in areas subject to regulations or requirements that are more stringent than the requirements contained herein. Where local, municipal, county, or state government requirements apply to the installation of the impressed-current cathodic protection system, such requirements govern, and this standard should be interpreted to supplement them. It is the purchaser's responsibility to supplement or modify this standard for compliance with these local requirements.

At a minimum, it is important that all of the requirements in this standard be met. An impressed-current cathodic protection system cannot be represented as an ANSI/AWWA D104-compliant system if it does not meet the minimum requirements of this standard.

Annual inspection and maintenance of the system are important to ensuring maximum tank life.

Chapter 6 of AWWA Manual M27, *External Corrosion Control for Infrastructure Sustainability*, addresses corrosion and corrosion protection for water tanks; and AWWA Manual M42, *Steel Water-Storage Tanks*, provides guidance on inspection and maintenance of welded steel tanks for water storage.

This standard does not cover tank disinfection procedures or cleaning and painting. ANSI/AWWA C652, *Disinfection of Water-Storage Facilities*, should be consulted for recommended procedures for disinfection of water storage facilities.

III.A. Purchaser Options and Alternatives. Proper use of this standard requires that the purchaser specify certain requirements. The purchaser may desire to modify,

*The word "system" and the phrase "cathodic protection system" are used herein broadly in place of the lengthy phrase "automatically controlled, impressed-current cathodic protection system for interior submerged surfaces of steel water storage tanks."

delete, or amplify sections of this standard to suit special conditions. It is strongly recommended that such modifications, deletions, or amplifications be made by supplementing this standard.

III.A.1 Options and Alternatives. The following list identifies aspects of the system that have more than one acceptable style, configuration, or value. The purchaser must specify the desired option for each of these items or specify that the system designer may select any appropriate option.

1. Whether compliance with NSF/ANSI 61, Drinking Water System Components—Health Effects, is required.
2. The type of anode.
3. The type of anode suspension system.
4. Required design life of the anode system.

III.A.2 Items to Be Provided by Purchaser or Installer. The following recommendations represent good practice but are not requirements of ANSI/AWWA D104. The contract documents should specify which party is to provide each of the following items:

1. When an impressed-current cathodic protection system is to be purchased under this standard, the purchaser should provide the following:
 - a. Access to the site on which the tank is located, including sufficient space to permit access to install, inspect, and test the system by customary methods.
 - b. Location from which alternating current (AC) power is to be provided to the rectifier unit.
 - c. A sufficient volume of water in the tank at the time of system installation to allow full system testing.
 - d. Safe access to the tank roof for installation and inspection of system components.
 - e. Certification that the tank roof is safe to access.
 - f. Any materials to be furnished by the purchaser for installation in the system by the system installer.
2. The system designer should submit design calculations, specifications, and construction drawings.
3. The system installer should furnish the following items:
 - a. All labor and materials, except materials provided by the purchaser, necessary to complete the installation of the system, including inspection and testing required by this standard.

b. Any additional work specified separately by the purchaser in the contract documents, such as disinfection of the tank.

c. Operation and maintenance manual.

III.A.3 Information to Be Specified by Purchaser. This standard provides minimum requirements for the design, construction, inspection, and testing of impressed-current cathodic protection systems for tanks without any designation of which party must perform these tasks or select the options. For this reason, the following information should be specified by the purchaser when contracting for an impressed-current cathodic protection system for interior submerged surfaces of a steel water storage tank:

1. Standard used, that is, ANSI/AWWA D104, Automatically Controlled, Impressed-Current Cathodic Protection for the Interior Submerged Surfaces of Steel Water Storage Tanks, of latest revision.
2. Compliance requirement for NSF/ANSI 61, Drinking Water System Components—Health Effects (see Sec. 4.1.2[Item 1]).
3. Gross capacity of the tank, the tank diameter, and the type of roof.
4. For elevated tanks, the style or shape of tank, the bottom capacity level (BCL), the head range, and the diameter and type of riser.
5. For ground-supported flat-bottom tanks, the top capacity level (TCL).
6. Chemical analysis of the water to be stored.
7. Water resistivity (for all sources of supply).
8. Water turbulence.
9. Operating temperature and flow rate.
10. Type and age of protective coatings.
11. Maximum anticipated coating deterioration expressed as a percentage of the total interior submerged coating surface area that is allowed to become bare before the coating is repaired or replaced (for design purposes).
12. Presence and approximate quantity of stainless steel, copper, brass, and other materials in the submerged portions of the reservoir.
13. Source of AC power.
14. Required design life of the anode system.
15. Location of the site.
16. Desired time for completion.

III.A.4 Information to Be Provided by the Bidder for an Impressed-Current Cathodic Protection System for Interior Submerged Surfaces of a Steel Water Storage Tank:

1. A description and requirements of the anode material, size, configuration, and suspension system.
2. A description of the quantity and location of the anodes.
3. A statement of the design basis of the system including tank size and configuration, all water properties, type of coatings, design percentage of bare steel surface protected, design life of the anodes, and cathodic polarization characteristics.
4. Outline of the recommended service and maintenance plan.

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

IV. Major Revisions. The major revisions to this edition of the standard include the following:

1. Language on dissimilar metals inside the tank below the top capacity level (TCL) has been added to Sec. 4.1.1. Related commentary has also been added to Sec. A.4.
2. Requirements for roof hand hole configuration have been added to Sec. 4.1.2.4.

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



**American Water Works
Association**

Dedicated to the World's Most Important Resource®

ANSI/AWWA D104-17
(Revision of ANSI/AWWA D104-11)

AWWA Standard

Automatically Controlled, Impressed- Current Cathodic Protection for the Interior Submerged Surfaces of Steel Water Storage Tanks

SECTION 1: GENERAL

Sec. 1.1 Scope

This standard describes automatically controlled, impressed-current cathodic protection systems intended to minimize corrosion of interior submerged surfaces of steel water storage tanks and 30-in. (750-mm) diameter and larger wet risers of elevated tanks.

This standard does not describe sacrificial (galvanic) anode-type cathodic protection systems or manually controlled, impressed-current systems.

Sec. 1.2 Purpose

The purpose of this standard is to provide the minimum requirements for automatically controlled, impressed-current cathodic protection for the interior submerged surfaces of steel water storage tanks, including design, system components, quality of work, and installation. Refer to appendix B for operation, monitoring, and maintenance considerations.

Sec. 1.3 Application

This standard can be referenced in specifications for designing and installing automatically controlled, impressed-current cathodic protection for the interior submerged surfaces of steel water storage tanks. The stipulations of this standard apply when referenced and then only to automatically controlled, impressed-current cathodic protection for the interior submerged surfaces of steel water storage tanks.

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 this standard. In any case of conflict, the requirements of this standard shall prevail.

ANSI/AWWA C652—Disinfection of Water-Storage Facilities.

ANSI/AWWA D100—Welded Carbon Steel Tanks for Water Storage.

ANSI/AWWA D102—Coating Steel Water-Storage Tanks.

ANSI/AWWA D103—Factory-Coated Bolted Carbon Steel Tanks for Water Storage.

NFPA[†] 70—National Electrical Code.

NSF[‡]/ANSI 61—Drinking Water System Components—Health Effects.

SECTION 3: DEFINITIONS

The following definitions shall apply in this standard:

1. *Anode*: The electrode of an electrochemical cell at which oxidation occurs. (Electrons flow away from the anode in the external circuit. It is usually at the electrode where corrosion occurs and metal ions enter solution.)

2. *Anode life*: The anticipated number of years of service before anode replacement is required. In this standard, the two types of anodes considered are (1) seasonal or temporary and (2) long life. The seasonal or temporary type of anode is considered to be a nominal 1-year life, and the long-life type of anode is considered to be a nominal 10-year minimum life.

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

[†] National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269.

[‡] NSF International, 789 North Dixboro Road, Ann Arbor, MI 48113.

3. *Cathode*: The electrode of an electrochemical cell at which reduction is the principal reaction. (Electrons flow toward the cathode in the external circuit.)

4. *Cathodic polarization*: The change in electrode potential in the negative (active) direction caused by current across the electrode/electrolyte interface.

5. *Cathodic protection*: A method of corrosion control that reduces the corrosion of a submerged metal surface by making that surface the cathode of an electrochemical cell.

6. *Coating*: All components of the protective coating system, the sum of which substantially isolates (electrically) the underlying metal from the electrolyte (water).

7. *Conductivity*: A measure of the ability of a material to carry an electric current, expressed in micromhos or Siemens per centimeter. In water, this depends on the total concentration of ionic species and temperature. Conductivity is the reciprocal of resistivity.

8. *Constructor*: The party that provides the work and materials for placement or installation.

9. *Corrosion*: The deterioration of a material, usually a metal, caused by a reaction with its environment.

10. *Corrosion potential*: The potential of a corroding surface in an electrolyte relative to a reference electrode under open-circuit conditions.

11. *Coupon*: An object of similar metallurgy to the structure.

12. *CSE*: Copper/copper sulfate reference electrode.

13. *Current density*: The current flowing to or from a unit area of an electrode surface.

14. *Driving voltage*: The potential difference between the anodes and the tank wall when the cathodic protection system is in operation.

15. *Electrode*: A conductive material through which an electric current enters or leaves an electrolyte.

16. *Electrode potential*: The potential of an electrode in an electrolyte as measured against a reference electrode. (The electrode potential does not include any resistance losses in potential in either the electrolyte or the external circuit. It represents the reversible work to move a unit of charge from the electrode surface through the electrolyte to the reference electrode.)

17. *Electrolyte*: A chemical substance or mixture containing ions that migrate in an electric field. For the purpose of this standard, *electrolyte* refers to

the water, including the chemicals contained therein, in contact with a submerged metal surface.

18. *Elevated tank:* A storage tank supported on a tower.

19. *Energized:* State of the cathodic protection system where the anodes are operating and protective current is flowing.

20. *Fresh water:* Water that is not saline; used for drinking, fire protection, or irrigation.

21. *Half-cell:* An electrode contacting an electrolyte; in common usage, any reference electrode.

22. *Half-cell potential:* The potential in a given electrolyte of one electrode of a pair. Potentials can only be measured and expressed as the difference between half-cell potentials of two electrodes.

23. *Holiday:* A void in the coating that will allow the passage of electrical current.

24. *Impressed current:* Direct current (DC) electrical current supplied by a power source external to the anode system.

25. *Impressed-current anode:* The positive electrode from which current is discharged and where oxidation (corrosion) occurs.

26. *Instant-off measurement:* Potential measurement taken with the current interrupted to determine the polarized potential that is free of IR drop.

27. *IR drop:* The voltage across a resistance in accordance with Ohm's law.

28. *Manufacturer:* The party that manufactures, fabricates, or produces materials or products.

29. *Ohm's law:* $E = IR$, where E = voltage in volts, I = current in amperes, and R = resistance in ohms.

30. *Polarization:* The change in open-circuit potential of an electrode resulting from the passage of current.

31. *Polarized potential:* The potential across the structure/electrolyte interface that is the sum of the corrosion potential and the cathodic polarization.

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

33. *Rectifier:* A device that converts alternating current (AC) to direct current (DC) required by a cathodic protection system.

34. *Reference electrode:* An electrode the open-circuit potential of which is constant under similar conditions of measurement, which is used for measuring the relative potentials of other electrodes.

35. *Reservoir*: A flat-bottom cylindrical tank having a shell height equal to or less than its diameter.

36. *Resistivity*: A measure of the resistance of a material to the passage of electric current, as a function of its geometry, expressed in ohm-cm. Resistivity is the reciprocal of conductivity.

37. *Standpipe*: A flat-bottom cylindrical tank having a shell height greater than its diameter.

38. *Tank-to-water potential*: The voltage difference between a submerged metallic structure and the electrolyte (water), which is measured with a reference electrode in contact with the electrolyte.

39. *Voltage*: An electromotive force or a difference in electrode potentials.

40. *Water tank*: An elevated water storage tank, a standpipe, or a reservoir of welded, bolted, or riveted steel construction.

SECTION 4: REQUIREMENTS

Sec. 4.1 Design

4.1.1 *Criteria for protection*. The cathodic protection system shall maintain the polarized tank-to-water potential at least as negative as -0.850 V to a CSE in contact with the stored water and submerged tank surface, or at least 100 mV of cathodic polarization. The formation or decay of polarization can be measured to satisfy this criterion.

CAUTIONARY NOTES:

1. The 100-mV polarization criterion is only applicable to steel water storage tanks not having corrosion cells caused by connection to more noble metals, such as copper, brass, or passive stainless steel (nonisolated dissimilar metals).

2. Dissimilar metals (e.g., stainless steel, copper, brass, etc.) more noble than carbon steel and installed inside the tank below the top capacity level (TCL) shall be electrically isolated from the carbon steel tank components to which they are attached. This isolation is required even if the attachment point of the dissimilar metals to the tank is above the maximum water level (MWL).

3. Cathodic protection current causes the pH on the submerged tank surfaces to increase due to the reduction reactions. Depending on the type of tank coating, this may cause blistering of the submerged coating. Tank-to-water potentials should not be more negative than -1.100 volt CSE.

4. The CSE potentials are at 25°C and should be adjusted for actual water temperature [E at temperature $T = E$ at 25°C + $k(T - 25°C)$ where $k = 0.9$ mV/°C]. For CSE potentials at 77°F, the temperature adjustment is E at temperature $T = E$ at 77°F + $k(T - 77°F)$ where $k = 0.5$ mV/°F.

4.1.1.1 Potential measurement. The potentials shall be measured free of the effect of voltage gradients (IR drops). The reference electrode may be positioned anywhere in the tank water.

4.1.2 *System design.* The cathodic protection system provided, according to this standard, shall achieve and maintain the criteria for protection (Sec. 4.1.1). In addition, the design of an impressed-current system shall include the evaluation of the tank information listed below:

1. Compliance requirement for NSF/ANSI 61, Drinking Water System Components—Health Effects.
2. Total interior submerged coating surface area to be protected.
3. Chemical analysis of the water to be stored.
4. Water resistivity (for all sources of supply).
5. Water turbulence.
6. Operating temperature and flow rate.
7. Type and age of protective coatings.
8. Maximum allowable coating deterioration (for design purposes) expressed as a percentage of the total interior submerged coating surface area that is allowed to become bare before the coating is repaired or replaced.
9. Specified design life of the anode system.

4.1.2.1 System capacity. Nominal current capacity of the rectifier shall be determined based on the estimated current density required for cathodic protection. The required current density is expressed in amps per unit area of total submerged bare surface. The required current density shall be determined for each specific tank and depends on the conductivity of the water, condition of the coating, temperature, aeration, and flow rate.

4.1.2.2 Design life. The design life of the cathodic protection system shall be calculated from the current discharge and consumption rate of the anodes. The magnitude of current shall be that necessary to protect the tank in accordance with the criteria listed under Sec. 4.1.1, considering future coating deterioration. The design of the impressed-current cathodic protection system shall be capable of providing sufficient current to protect the tank for the full design life of the cathodic protection system.

4.1.2.3 Output voltage capacity. The output voltage capacity is a function of the protective current requirement and the total circuit resistance, in accordance with Ohm's law. The circuit resistance is composed of the anode-to-water resistance, the wiring resistance, and the coating resistance.

4.1.2.4 Anode configuration. The anode array shall provide and maintain a uniform distribution of protective current without exceeding the potential limits established in Sec. 4.1.1. The anode array shall provide and maintain low-circuit resistance consistent with the design life of the anode system and be designed to prevent electrical shorting to the tank.

Where hand holes are to be cut in the top of the tank for anode installation and future access, the hand hole design shall provide a watertight seal between the roof and hand hole cap plate to prevent rain water and other contaminants from entering the tank.

4.1.2.5 Riser circuit. For an elevated tank riser 30 in. (750 mm) in diameter or larger, additional system capacity shall be provided. A separately controlled circuit shall be provided for cathodically protecting the riser.

Sec. 4.2 System Components

4.2.1 *Automatic rectifier.* Rectifier units shall provide full-wave rectification using either silicon or selenium rectifying elements. The rectifier shall be capable of varying the current output from 1 to 100 percent of its rated capacity.

The rectifier shall be capable of automatically adjusting the current output so as to maintain the tank-to-water potential within ± 25 mV of the criterion for protection (Sec. 4.1.1).

Protection and monitoring devices shall be provided, including disconnect switches; circuit breakers; output voltmeter; ammeters; potential meter; and surge, lightning, and overload protection.

The tank-to-water potential used to control the current output shall be derived from a long-life electrode positioned in the tank electrolyte.

NOTE: An additional control circuit may be used to limit the maximum current output of the rectifier to restrict the tank-to-water potential values for a specified protective coating.

4.2.2 *Reference electrodes.* Copper/copper sulfate reference electrodes shall be used for freshwater applications. For other types of water, the type of reference electrode shall be compatible with the water chemistry. The permanent reference electrode used to measure the tank-to-water potential for controlling the current output of the rectifier shall be designed to maintain a stable potential in continuous

immersion in the water for a minimum of 10 years. The reference electrode(s) shall have a potential drift of less than 10 mV. The reference electrode lead wire shall be insulated with no bare metallic components in contact with the water.

4.2.3 *Anode materials.*

4.2.3.1 Seasonal or temporary anodes. Seasonal or temporary anodes shall be aluminum alloy and shall be of an alloy that corrodes uniformly.

4.2.3.2 Long-life anode systems. Long-life anode systems shall have an anode design life of at least 10 years. Long-life anodes shall be high-silicon cast iron, platinized niobium, platinized titanium, or mixed metal oxide coated titanium, unless otherwise specified by the purchaser. The number and size of the anode(s) shall be selected based on the consumption rate of the anode material and the current output of the system.

4.2.3.3 Cable insulation. The anode lead wire shall be insulated.

4.2.4 *Anode suspension systems.* Suspension materials shall be designed for a minimum 10-year life for the conditions inside the tank, unless otherwise specified by the purchaser.

4.2.4.1 Anode suspension systems for tanks subject to icing. Anode suspension systems for tanks subject to icing shall be designed to be resistant to ice damage. There are three types of suspension systems: type A, horizontal system; type B, extendable vertical system; and type C, suspended vertical system. The method of suspension for each of these systems shall be as follows:

4.2.4.1.1 Type A, horizontal system. The horizontal system shall be positioned to prevent contact with ice formations at the high-water level maintained during winter operations. The submerged radial rope system shall be attached to anchors welded or bolted to the side wall of the tank. The rope system may also include flotation buoys to help position the system within the tank.

4.2.4.1.2 Type B, extendable vertical system. The extendable assembly shall be designed to stretch with the movement of ice formations and return to the vertical position when there are no ice formations. The extendable assembly shall be attached to clevises that are welded or bolted to the roof of the tank.

4.2.4.1.3 Type C, suspended vertical system. For the suspended vertical anode system, a radial rope system is floated on buoys. Wire anodes are suspended from the floating support and are weighted or anchored to the tank floor.

4.2.4.2 Anode suspension systems for tanks not subject to icing. Anode suspension systems for tanks not subject to icing include the following types of

systems: horizontal and vertical. The method of suspension for each of these systems shall be as follows:

4.2.4.2.1 *Horizontal system.* A submerged circular rope system shall be attached to anchors welded or bolted to the side wall of the tank. The rope system may also include flotation buoys to help position the horizontal system within the tank.

4.2.4.2.2 *Vertical system.* The anode lead wire for vertical suspended anode systems shall be attached to clevises welded or bolted to the roof of the tank.

4.2.5 *External wiring.* Wiring on the outside of the tank shall be installed in rigid steel conduit and shall be in accordance with the National Electrical Code, NFPA 70, and all applicable local codes.

Sec. 4.3 Installation

4.3.1 *General.* Electrical work shall be in accordance with the National Electrical Code, NFPA 70, and applicable local codes.

All welding, cutting, and coating work required in conjunction with the installation of the cathodic protection system shall conform to applicable requirements of AWWA standards ANSI/AWWA D100, ANSI/AWWA D102, and ANSI/AWWA D103. This work usually includes the installation of fittings, anchors, and brackets and the repair of any damaged coating. Coating material used for repair of existing field-applied coatings shall be of the same generic type and should have the same regulatory approval as the existing coating systems. Surface preparation shall be as recommended by the coatings manufacturer. Damaged areas shall be feathered, and coatings shall be applied in the same order and number of coats as the original systems. Repair of factory-applied coatings shall be as recommended by the tank manufacturer.

Work within the tank shall be evaluated by the purchaser to determine the need for disinfection. Disinfection work shall be in accordance with ANSI/AWWA C652.

An external disconnect switch shall be provided in the AC primary wiring, and the rectifier case shall be properly grounded.

The rectifier shall be installed at a convenient height above the ground so that it may be readily serviced unless otherwise specified by the purchaser.

Anodes shall be installed at the locations and by the methods specified by the system designer.

Lead wires and connections shall be waterproof. The system shall be tested to ensure that there are no short circuits between the positive lead wire and the tank

structure. The positive lead wire shall be connected to the anodes, and the negative conductor shall be properly connected to the protected structure.

Underwater splices to the positive lead wire shall not be used. Connections between the positive lead wire and conductors from anodes shall be mechanically secure, shall be electrically conductive, and shall be sealed to prevent moisture penetration.

There shall be only one electrical splice within the tank, above the MWL, for each reference electrode.

NOTE: Electrical continuity between sections of the tank is necessary. Welded tanks ensure electrical continuity, but tanks that are bolted or riveted may require electrical bonding of tank sections.

4.3.2 Cleanup. On completion of the installation, rubbish and other unsightly material caused by the cathodic protection construction operations shall be removed, and the premises shall be left in as good a condition as found at the start of the project.

4.3.3 Materials. Materials shall comply with the requirements of the Safe Drinking Water Act and other federal, state or provincial, and local requirements.

SECTION 5: VERIFICATION

Sec. 5.1 Inspection and Handling

The rectifier shall be factory tested for efficiency and defects in material or workmanship. The rectifier shall be inspected at the site to ensure that internal connections are mechanically secure and that no damage occurred during shipping. Only new, undamaged rectifiers shall be installed. Handle the rectifier carefully during installation to avoid damage and ensure proper operation.

Anodes shall be inspected for damage and to ensure compliance with the design for material, size, length, lead wire connection, and lead wire insulation. Avoid cracking, loosening of lead wire connection, or otherwise damaging anodes or wiring during handling and installation.

Sec. 5.2 Testing

After the installation is completed, the system shall be energized, tested, and adjusted. Final testing shall not be conducted until the system has had time to polarize. A representative potential profile shall be conducted to verify that the tank-to-water potential satisfies the criteria for protection as described in Sec. 4.1.1.

The system shall be field tested by conducting IR drop-free potential measurements. The instant-off measurement is the most commonly used measurement for this test.

If the system is not to be commissioned until after the internal coating warranty inspection, the transformer-rectifier disconnect switch shall be locked in the off position.

Sec. 5.3 Operation and Maintenance Manual

An operation and maintenance manual for the cathodic protection system shall be provided and shall include the results of the testing required by Sec. 5.2. In addition, the following information shall be included:

1. Name and address of system installer.
2. System design criteria (Sec. 4.1.2).
3. Date that cathodic protection installation was completed and tested.
4. As-built drawings showing anode composition, anode configuration, anode suspension, and support system.
5. Operation and maintenance instructions.

This page intentionally blank.

APPENDIX A

Commentary and Additional Information

This appendix is for information only and is not a part of ANSI/AWWA D104.

SECTION A.1: SCOPE

The purpose of this appendix is to provide additional information regarding corrosion protection for the interior submerged surface of steel water storage tanks.

Steel surfaces submerged in water are subject to galvanic corrosion. Galvanic corrosion is a natural, continuous electrochemical process that generates direct electrical current, resulting from differences in potential between two metal surfaces, and removes metal from unprotected surfaces in contact with water. The methods used to control corrosion should be governed by the rate of corrosion and the cost of maintaining the tank over its service life. Cathodic protection will only control corrosion on the interior tank surfaces that are submerged.

SECTION A.2: DETERMINATION OF NEED FOR CATHODIC PROTECTION

For internally coated steel tanks, there may be holidays in protective coatings. Where mitigation of corrosion on the tank interior is found to be either necessary or beneficial for protection of the tank's interior surfaces (either in lieu of or supplemental to protective coatings), cathodic protection is recommended. For bare steel tanks where waters are corrosive, cathodic protection is also recommended to be used for corrosion control of the interior submerged surfaces.

SECTION A.3: PRINCIPLES OF CATHODIC PROTECTION

Cathodic protection uses direct current to control the corrosion process and reduce corrosion of submerged surfaces. Cathodic protection systems can be installed on new or existing tanks and on coated or uncoated tanks.

Cathodic protection current requirements for control of corrosion vary with changes in water level, coating deterioration, temperature, water chemistry, and water turbulence. The effectiveness of a cathodic protection system is determined by measuring the voltage difference between the submerged surface of the tank and a copper/copper sulfate reference electrode submerged in the tank contents. This measurement is commonly called the *tank-to-water potential*. When the tank-to-water potentials measured at several locations representing the entire submerged surface area of the tank meet the criteria for protection, corrosion protection is considered effective (Sec. 4.1.1 of ANSI/AWWA D104).

Cathodic protection is generally used in conjunction with protective coatings. Organic coatings are permeable to some degree. Coatings used with cathodic protection should be resistant to an alkaline environment, should not absorb water, and should be well bonded to the steel substrate. For internally coated tanks, cathodic protection will extend the time interval between recoating of submerged surfaces.

SECTION A.4: DESIGN

The current required for cathodic protection of a well-coated tank is much lower than for a bare or poorly coated tank. The combination of coatings and cathodic protection is often the most effective and most economical method of corrosion control for the interior submerged surfaces of steel water storage tanks.

Cathodic protection can also be used for corrosion control of the interior submerged surfaces of bare steel tanks. For bare steel tanks, the cost of cathodic protection should be compared with the cost of metal loss, repairs, leakage, service disruption, reduction in tank life, and water degradation. For coated steel tanks, also consider the cost of recoating interior submerged surfaces and the savings created by extending the recoating interval.

A.4.1.1 Dissimilar metals. For tank components exposed to the stored water, construction with dissimilar metals more noble (stainless steel, copper, brass) than the carbon steel tank components to which they are attached is currently prohibited by AWWA carbon steel tank standards (ANSI/AWWA D100, ANSI/AWWA D103, and ANSI/AWWA D107) unless those dissimilar metal components are electrically isolated from the carbon steel tank at all points of connection.

When dissimilar metal internal components are not electrically isolated and they are in contact with the water or condensation, corrosion of the carbon steel tank will occur. Experience has also shown that even exposure of nonisolated dissimilar

metals above the liquid level on open top tanks can be subject to accelerated dissimilar metals corrosion. Also, nonisolated stainless-steel components will interfere with the effectiveness of any cathodic protection systems that may be in place.

In most cases, stainless-steel components can be isolated from the carbon steel tank using alternative connection details. In cases where it is believed that they cannot be isolated from the tank, check with tank manufacturers and consultants for alternative details that can provide isolation.

In cases where electrical isolation of stainless-steel internal components below the overflow level has been determined to not be possible, it is recommended that the stainless-steel components be lined and coated with a suitable dielectric coating. It is the responsibility of the owner or specification writer, and not the responsibility of the painting contractor, to determine whether any dissimilar metals exist and, if so, how the dissimilar metals are to be treated with respect to the coating system. In such case where coatings are used to reduce the exposed cathodic surface of nonisolated dissimilar metals, the coating system recommendations should be provided by the selected coating manufacturer, including validation that the recommended coating system has sufficient dielectric strength to provide a suitable barrier and that the coating can be properly applied and maintained to the components being considered.

It should be noted that the solutions to dissimilar metals corrosion generally are contained in the details and configuration of the construction and the tank and its components. The coating specification cannot change those details, but it can address how and where to apply dielectric coatings to reduce the exposed cathodic surface, thereby reducing the effects of dissimilar metals corrosion.

SECTION A.5: INSTALLATION

The cathodic protection system is typically installed by a design–install contractor. Regardless of who installs the cathodic protection system, the installation should be completed in accordance with the project specifications.

SECTION A.6: ENERGIZING SYSTEM

The energizing, testing, and adjusting of the system shall be in accordance to Sec. 5.2 of ANSI/AWWA D104. As noted in Sec. 5.2, for new tanks, the cathodic

system might not be energized and made fully operational until the performance of the internal coating system has been assessed after the coating system warranty inspection and, if necessary, repaired. Sufficient time is necessary for the system to polarize, which may vary from several hours to several weeks or more, depending on the tank configuration, coating system, and water chemistry. Testing should not commence until the system has been polarized.

SECTION A.7: AFFIDAVIT OF COMPLIANCE

An affidavit of compliance with all applicable provisions of this standard may be requested. The affidavit should be signed by a corrosion specialist and the system installer. As used here, a corrosion specialist is a person who is accredited by NACE International as a senior corrosion technologist, corrosion specialist, or cathodic protection specialist.

SECTION A.8: CATHODIC PROTECTION AND TANK-MOUNTAIN ANTENNAS

Tank-mounted antennas have not been found to cause interference with the performance of the cathodic protection system, and the cathodic protection systems have not been found to cause interference with the performance of the antenna signals.

APPENDIX B

Operation Guidelines for Cathodic Protection Systems

This appendix is for information only and is not a part of ANSI/AWWA D104.

SECTION B.1: GENERAL

The owner should refer to reports and manuals provided by the constructor (Sec. 5.3 of ANSI/AWWA D104).

SECTION B.2: MONITORING

Monitor the impressed-current cathodic protection system at least bimonthly to ensure continuous operation by checking the volts, amps, and potential measurements as indicated on the meters in the rectifier unit. Annually perform a tank-to-water potential survey using a calibrated portable reference electrode in accordance with Sec. 5.2. If any system component is damaged or a malfunction is discovered, the system should be tested and repaired.

SECTION B.3: RECORDS

Records of the current and potential testing should be retained for the last three years to verify that the system is performing consistently.

In addition to the reports and manuals provided by the constructor (Sec. 5.3 of ANSI/AWWA D104), the following information should be maintained to help the owner monitor and operate the system:

1. Tank information, including name and address of the tank constructor, date of erection, dimensions, including high and low water levels, and capacity of the tank.
2. Chemical analysis of water and history of ice conditions.
3. Type of coatings applied and when applied.
4. Service reports by constructor, corrosion specialist, or service company. As used here, a corrosion specialist is a person who is accredited by NACE

International as a senior corrosion technologist, corrosion specialist, or cathodic protection specialist.

5. If the tank is emptied, the condition of the coating, evidence of corrosion, or any calcareous buildup on the surface of the tank should be recorded.

NOTE: Severe ice formation in tanks should be prevented using operating procedures such as water circulation or other acceptable methods. If the interior of the tank is entirely frozen or if the tank is drained when heavy accumulations of ice exist, the anode system should be inspected and repaired as required.

APPENDIX C

Service and Maintenance of Impressed-Current Cathodic Protection Systems

This appendix is for information only and is not a part of ANSI/AWWA D104.

SECTION C.1: SCOPE

A cathodic protection system should be tested and maintained to ensure the system continues to control corrosion on the interior submerged surface of the tank. It is recommended that the periodic testing and maintenance of the cathodic protection system be performed by the system constructor or a corrosion specialist. As used here, a corrosion specialist is a person accredited by NACE International as a senior corrosion technologist, corrosion specialist, or cathodic protection specialist.

SECTION C.2: ANNUAL INSPECTION AND POTENTIAL TESTING

Inspection of the system should be performed at least annually and should include tank-to-water potential measurements to monitor the effectiveness of the system for the submerged surfaces of the tank. When a tank-to-water potential survey is conducted, the measurements should be taken at five separate locations. The method of conducting the measurements should be in accordance with Sec. 5.2 of ANSI/AWWA D104 using a calibrated, portable reference electrode. A report of the inspection and testing should include observed measurements, an evaluation and interpretation of the measurements, and recommendations for continued performance of the system.

SECTION C.3: SEASONAL ANODE SERVICE

Seasonal anode systems usually require annual replacement. This work can be part of an annual service agreement. For tanks subject to freezing, anode replacement should be performed in the spring. After the anodes are replaced, the system

should be energized, tested, and adjusted in accordance with methods used to verify the criteria for cathodic protection (Sec. 5.2 of ANSI/ AWWA D104).

SECTION C.4: REPAIRS AND REPLACEMENTS

System components, such as the rectifier, anodes, and stationary reference electrodes, do not require annual replacement but should be inspected annually for maintenance and repair. For parts and installation services for these components of the cathodic protection system, the system constructor or corrosion specialist should be consulted. As used here, a corrosion specialist is a person accredited by NACE International as a senior corrosion technologist, corrosion specialist, or cathodic protection specialist.

This page intentionally blank.



American Water Works Association

6666 West Quincy Avenue
Denver, CO 80235-3098
T 800.926.7337
www.awwa.org



Dedicated to the world's most important resource, AWWA sets the standard for water knowledge, management, and informed public policy. AWWA members provide solutions to improve public health, protect the environment, strengthen the economy, and enhance our quality of life.

1P-2M 44104-2017 (12/17) IW



Printed on Recycled Paper

ISBN 978-1-62576-274-0



9 781625 762740