ANSI/AWWA D106-16
(Revision of ANSI/AWWA D106-10)

American Water Works Association
Dedicated to the World's Most Important Resource®

AWWA Standard

Sacrificial Anode Cathodic Protection Systems for the Interior Submerged Surfaces of Steel Water Storage Tanks

Effective date: June 1, 2016.
First edition approved by AWWA Board of Directors June 20, 2010.
This edition approved Jan. 16, 2016.
Approved by American National Standards Institute Oct. 30, 2015.

American Water Works Association | STANDARD | Since 1881

Approved American National Standard ANSI

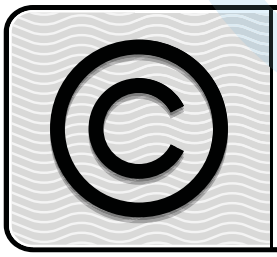
AWWA Standard

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 supply 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.



This AWWA content is the product of thousands of hours of work by your fellow water professionals. Revenue from the sales of this AWWA material supports ongoing product development. Unauthorized distribution, either electronic or photocopied, is illegal and hinders AWWA's mission to support the water community.

ISBN-13, print: 978-1-62576-151-4 eISBN-13, electronic: 978-1-61300-374-9
DOI: http://dx.doi.org/10.12999/AWWA.D106.16

Committee Personnel

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

David H. Kroon, *Chair*

W.J. Czaska, CB&I, Plainfield, Ill. (AWWA)
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 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 Elevated Tanks, Standpipes, and Reservoirs, 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, Emerald Coast Utilities Authority, Pensacola, Fla. (AWWA)
M.F. Gaffey, Naval Facilities Expeditionary Warfare Center, Washington Navy Yard, Washington, D.C. (AWWA)
C.P. Harder, City of Fort Worth, Fort Worth, Texas (AWWA)
E.J. King, Connecticut Water Company, Clinton, Conn. (AWWA)
M.J. Mazurek, Baltimore County Department of Public Works, Towson, Md. (AWWA)
J.L. Ortiz, San Francisco Public Utilities Commission, San Francisco, Calif. (AWWA)
J. Travers, City of Richardson, Richardson, Texas (AWWA)

General Interest Members

D.M. Algranti, Albert A. Webb Associates, Riverside, Calif. (AWWA)
J.D. Brock, Poggemeyer Design Group Inc., Bowling Green, 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)
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)
G.R. Stein,† Tank Industry Consultants, Indianapolis, Ind. (AWWA)
J.I. Strand, Short Elliott Hendrickson Inc., Chippewa Falls, Wis. (AWWA)
T.A. Tovey, CH2M, Bellevue, Wash. (AWWA)

Producer Members

G.A. Burke, Caldwell Tanks Inc., Louisville, Ky. (AWWA)
W.J. Czaska, CB&I, Plainfield, Ill. (AWWA)
J.W. Davis, Tnemec Company, North Kansas City, Mo. (AWWA)
B.E. Kromer, Tank Builders Inc., Euless, Texas (AWWA)
K. McGuire, CST Storage, Parsons, Kan. (AWWA)
R.L. Moore, Pure Technologies Ltd., St. Louis, Mo. (AWWA)
L.D. Scott, Paso Robles 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.

This page intentionally blank.

Foreword

This foreword is for information only and is not a part of ANSI/AWWA D106.*

I. Introduction.

I.A. *Background.* This standard describes sacrificial anode cathodic protection systems for the interior submerged surfaces of steel water storage tanks. This standard does not cover automatically controlled impressed current systems (see ANSI/AWWA D104) or impressed current systems with manually controlled rectifiers.

I.B. *History.* Cathodic protection equipment, which was previously included in Section 4 of AWWA D102-64, Painting and Repainting Steel Tanks, Standpipes, Reservoirs, and Elevated Tanks for Water Storage, was not included in AWWA D102-78, Painting Steel Water-Storage Tanks. Therefore, AWWA D104 was developed by the Standards Committee on Steel Elevated Tanks, Standpipes, and Reservoirs to include this information. The first edition of ANSI/AWWA D104 was approved by the AWWA Board of Directors on Jan. 27, 1991. It has gone through a series of revisions since that time. Subsequently, in 2004, the need for a sacrificial anode cathodic protection standard was identified, resulting in the development of AWWA D106. The first edition of the standard was approved by the AWWA Board of Directors on June 20, 2010. This second edition was approved on Jan. 16, 2016.

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. An advisory program formerly administered by USEPA, Office of Drinking Water, discontinued on Apr. 7, 1990.

2. Specific policies of the state or local agency.

3. 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.

4. 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 D106 does not address additives requirements. 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 flaws 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 arrest corrosion at flaws in the submerged coated surface. Properly applied coatings reduce the bare surface area requiring protection and reduce the amount of current required to protect the surface.

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

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

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 also reduces the required frequency of coating maintenance. Cathodic protection or coatings alone can reduce corrosion on the interior submerged surfaces; however, the combination of coatings and cathodic protection is normally more economical and effective than using coatings or cathodic protection alone.

II.B. *Cathodic Protection.* The two major components of a sacrificial anode cathodic protection system are the anodes and the test box for monitoring and current control. In lieu of a test box, the manufacturer may provide an alternative means for monitoring and current control. The range of sacrificial anode output current capacity required for a specific tank is determined by estimating 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 where recoating is necessary. In potable water, current density requirements can range from 0.5 to 5.0 mA/ft^2 (5.4 to 53.8 mA/m^2) of bare steel surface. Applications involving turbulence, high temperature, or both 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 interior tank surface. As a rule, sacrificial anode systems for newly coated tanks should have sufficient current capacity to protect the anticipated bare submerged surface area before coating repairs or replacement.

A sacrificial anode cathodic protection system should include a test box or other means for measuring tank-to-water potentials and adjusting the current output of the sacrificial anodes. One or more long-life reference electrodes should be included in the system to monitor the protection levels on the submerged steel surfaces. The reference electrode is used to monitor the tank-to-water potential, free of IR drop error. IR drop must be eliminated or minimized to accurately determine the potential between the tank surface and the reference electrode submerged in the tank. The test box allows for the anode current to be instantaneously interrupted, providing an IR drop-free potential that closely approximates the polarized potential of the tank.

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 sacrificial anode cathodic protection systems* for interior submerged surfaces have been in service for more than 30 years. Proper design and maintenance of sacrificial anode 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 sacrificial anode 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. A sacrificial anode cathodic protection system cannot be represented as a system compliant with ANSI/AWWA D106 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.

AWWA Manual M27, *External Corrosion Control for Infrastructure Sustainability*, chapter 6, 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 assumes the tank owner utilizes procedures or equipment to prevent freezing of the water in the tank. Where the possibility of freezing exists, the owner should implement procedures or equipment to prevent freezing. The purchaser is referred to National Fire Protection Association (NFPA) document NFPA 22, Standard for *Water Tanks for Private Fire Protection*, for heater sizing. Purchasers are cautioned against allowing ice to form inside a tank because it may damage system components and even the tank itself.

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.

* The word *system* and the phrase *cathodic protection system* are used hereinafter broadly in place of the lengthy phrase *sacrificial anode cathodic protection system for interior submerged surfaces of steel water storage tanks*.

III.A. *Purchaser Options and Alternatives.* Proper use of this standard requires that the purchaser specify certain requirements. The purchaser may desire to modify, 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 connection (included in Sec. III.A.3, Information to Be Specified by Purchaser).

a. Direct connection of the anodes to the tank.

b. Connection of the anodes through a test box that allows for monitoring and adjustment of anode current output.

III.A.2. Items to Be Provided by Purchaser or Installer. The following recommendations represent good practice about what each party should provide, but they are not requirements of ANSI/AWWA D106. The contract documents should specify which party is to provide each of the following items.

1. When a sacrificial anode 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 to be built, including sufficient space to permit access to install, inspect, and test the system by customary methods.

b. A sufficient volume of water in the tank at the time of system installation to allow full system testing.

c. Safe access to the tank roof for installation and inspection of system components.

d. Certification that the tank roof is safe to access.

e. 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 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 a sacrificial anode cathodic protection system for interior submerged surfaces of a steel water storage tank:

1. Standard used—that is, ANSI/AWWA D106, Sacrificial Anode Cathodic Protection Systems 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[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 submerged coating surface area that is allowed to become bare before the coating is repaired or replaced (for design purposes).

12. Cathodic polarization characteristics.

13. Anode metal and alloy required (see Sec. 4.1.2.3).

14. Type of anode connection required (see Sec. 4.1.2.4).

15. Required design life of the anode system.

16. Location of the site.

17. Desired time for completion.

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

1. A description of the anode material, size, and configuration.
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, and design life of the anodes.
4. The type of anode connection employed in the design.
5. Outline of the recommended service and maintenance plan.

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

1. Language regarding dissimilar metals inside the tank below the TCL has been added (Sec. 4.1.1).
2. Requirements for roof hand-hole configuration have been added (Sec. 4.1.2.4).
3. Numerous editorial revisions have been made throughout the standard to improve clarity.

V. Comments. If you have any comments or questions about this standard, please contact 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 the group at standards@awwa.org.

This page intentionally blank.

ANSI/AWWA D106-16
(Revision of ANSI/AWWA D106-10)

American Water Works Association
Dedicated to the World's Most Important Resource®

AWWA Standard

Sacrificial Anode Cathodic Protection Systems for the Interior Submerged Surfaces of Steel Water Storage Tanks

SECTION 1: GENERAL

Sec. 1.1 Scope

This standard describes sacrificial anode cathodic protection systems intended to minimize corrosion of interior submerged surfaces of steel water storage tanks.

This standard does not describe automatically or manually controlled impressed current systems.

Sec. 1.2 Purpose

The purpose of this standard is to provide the minimum requirements for sacrificial anode cathodic protection systems for the interior submerged surfaces of steel water storage tanks, including design, system components, quality of work, installation, operation, and maintenance.

Sec. 1.3 Application

This standard can be referenced in specifications for designing and installing sacrificial anode cathodic protection systems for the interior submerged surfaces of steel water storage tanks. The stipulations of this standard apply when referenced and then only to sacrificial anode cathodic protection systems for the interior submerged surfaces of steel water storage tanks.