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

American Water Works Association
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AWWA Standard

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

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AWWA Standard

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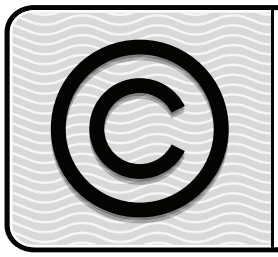

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Contents

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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/ft^2 (5.4 to 53.8 mA/m^2) 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.

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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.