# Standard
# Recommended Practice

# Galvanic Anode Cathodic Protection of Internal Submerged Surfaces of Steel Water Storage Tanks

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## Foreword

The purpose of this standard recommended practice is to present the procedures and practices used in providing galvanic anode cathodic protection (CP) to the normally submerged steel surfaces inside water storage tanks. This standard provides owners, engineers, and contractors with specific guidelines for the design and installation of these CP systems; methods for determining the effectiveness of these systems; and recommendations for the operation and maintenance of these systems. This standard is applicable to water storage tanks of various sizes used in municipal water supply and fire protection, including elevated tanks and flat-bottom tanks at ground level. Although the general principles outlined in this standard are applicable to all such tanks, the galvanic anode CP system described in this standard may not be practical for relatively large tanks.

This standard was originally prepared in 1996 by NACE Task Group (TG) T-7L-1, a component of Unit Committee T-7L on Cathodic Protection. It was revised in 2004 by TG 284 on Cathodic Protection, Galvanic Anode for Internal Submerged Surfaces of Steel Water Storage Tanks—Review of NACE Standard RP0196, "Galvanic Anode Cathodic Protection of Internal Submerged Surfaces of Steel Water Storage Tanks." TG 284 is administered by Specific Technology Group (STG) 05 on Cathodic/Anodic Protection. It is sponsored by STG 11 on Water Treatment and STG 35 on Pipelines, Tanks, and Well Casings. This standard is issued by NACE under the auspices of STG 05.

In NACE standards, the terms *shall*, *must*, *should*, and *may* are used in accordance with the definitions of these terms in the *NACE Publications Style Manual*, 4th ed., Paragraph 7.4.1.9. *Shall* and *must* are used to state mandatory requirements. The term *should* is used to state something good and is recommended but is not mandatory. The term *may* is used to state something considered optional.

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# Galvanic Anode Cathodic Protection of Internal Submerged Surfaces of Steel Water Storage Tanks

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## Section 1: General

1.1 This standard presents recommended procedures for using galvanic anodes to apply CP to the internal submerged surfaces of steel tanks used for the storage of potable and nonpotable fresh waters.

1.2 It is recognized that impressed current systems are used extensively for CP of the internal surfaces of water storage tanks; however, this standard addresses only galvanic anode systems. For a description of impressed CP current systems, refer to NACE Standard RP0388.[1]

1.3 Natural waters, as used in this standard, include both potable and nonpotable fresh water—including reclaimed water—associated with water supply, irrigation, and fire protection systems.

1.4 The ground level and elevated storage tanks considered in this standard are of welded, bolted, or riveted-steel construction, and include many shapes and sizes.

1.5 CP as described in this standard may be used alone to control corrosion of submerged steel surfaces or may be used as a complement to the protection provided by protective coatings or other procedures.[2] CP cannot protect surfaces that are not submerged; these surfaces must be protected by coatings alone.

1.6 CP may be installed to control corrosion in both newly constructed and existing tanks. When CP is used on existing tanks, it may be necessary to drain the tank during installation.

1.7 It is recognized that the tanks under consideration are often associated with potable water and fire protection systems that may be subject to public health and safety regulations.[3] This standard shall not infringe on those regulations. Proper disinfection of the tanks may be required after installation.

1.8 The provisions of this standard should be applied under the direction of a competent corrosion engineer. The term “corrosion engineer,” as used in this standard, refers to a person who, by reason of knowledge of the physical sciences and the principles of engineering and mathematics as acquired by professional education and related practical experience, is qualified to practice corrosion control, including CP, for water storage tanks. Such persons may be Registered Professional Engineers or persons recognized as being qualified or certified as Corrosion Specialists or CP Specialists by NACE if their professional activities include suitable experience in corrosion control and CP.

1.9 This standard may not be applicable in all situations. The corrosion engineer may consider alternative corrosion control methods.

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## Section 2: Definitions

**Anode:** The electrode of an electrochemical cell at which oxidation occurs. Electrons flow away from the anode in the external circuit. Corrosion usually occurs and metal ions enter the solution at the anode.

**Anode Circuit:** The path from a single anode or multiple anodes connected through a shunt, a resistor, and the connection to the tank.

**Calcareous Coating:** A layer consisting of calcium carbonate and other salts deposited on the surface. When the surface is cathodically polarized as in CP, this layer is the result of the increased pH adjacent to the protected surface.

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

**Cathodic Protection (CP):** A technique to reduce the corrosion of a metal surface by making that surface the cathode of an electrochemical cell.

**Cathodic Protection (CP) Coupon:** A metal specimen made of similar material as the structure under investigation, which is connected to the external surface of, and immersed in, the electrolyte adjacent to the structure being protected by CP.

**Coating:** A liquid, liquefiable, or mastic composition that, after application to a surface, is converted into a solid protective, decorative, or functional adherent film.

**Conductivity:** (1) A measure of the ability of a material to conduct an electric charge. It is the reciprocal of resistivity. (2) The current transferred across a material (e.g., coating) per unit potential gradient.

**Corrosion:** The deterioration of a material, usually a metal, that results from a reaction with its environment.

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

**Driving Voltage:** The potential difference between the galvanic anodes and the tank wall when the CP system is in operation.

**Electrode:** A conductor used to establish contact with an electrolyte and through which current is transferred to or from an electrolyte.

**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.)

**Electrolyte:** A chemical substance containing ions that migrate in an electric field. For the purpose of this standard, electrolyte refers to the water, including the dissolved chemicals, in the tank.

**Galvanic Anode:** A metal that provides sacrificial protection to another metal that is more noble when electrically coupled in an electrolyte. This type of anode is the electron source in one type of CP.

**Holiday:** A discontinuity in a protective coating that exposes unprotected surface to the environment. For the purpose of this standard, it is a bare spot in a coating that exposes tank internal metal surface to the stored water.

**Impressed Current:** An electric current supplied by a device employing a power source that is external to the electrode system. (An example is direct current for CP.)

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

**Polarization:** The change from the open-circuit potential as a result of current across the electrode/electrolyte interface.

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

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

**Resistivity:** (1) The resistance per unit length of a substance with uniform cross section. (2) A measure of the ability of an electrolyte (e.g., soil) to resist the flow of electric charge (e.g., CP current). Resistivity data are used to design a groundbed for a CP system. For the purpose of this standard, resistivity is a measure of the ability of the water to resist the flow of current. Water resistivity is used in the design of the galvanic anode CP system.

**Shielding:** (1) Protecting; protective cover against mechanical damage. (2) Preventing or diverting CP protection current from its natural path.

**Tank-to-Water Potential:** The voltage difference between a submerged metallic portion of the tank and the water (electrolyte), which is measured with a reference electrode in contact with the water.

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## Section 3: Determination of Need for CP

### 3.1 Introduction

3.1.1 Steel tank surfaces submerged in natural waters are subject to corrosion. The methods and procedures used to control corrosion should be governed by the rate of corrosion and the cost of maintaining the tank, including the water quality and planned useful life of the tank.

3.1.2 Corrosion control by use of coatings alone is possible only if the coating is continuously maintained to provide complete coverage of the surface to be protected. All coatings are subject to damage and deterioration. CP may not be effective under disbonded coating.

3.1.3 CP is effective in controlling corrosion only on submerged metal surfaces during submersion. It does not reverse structural damage already caused by corrosion.

### 3.2 Coated Steel Tanks

3.2.1 CP should be used to prevent corrosion on submerged, coated steel tank surfaces where holidays exist—or are anticipated—and where corrosion would occur as a result of those holidays.

3.2.2 If the water is sufficiently corrosive to justify the use of a coating, then CP is also justified and provides a greater degree of protection than when either method is used alone.

3.2.3 Properly designed and maintained CP systems extend the useful life of those coatings that are compatible with CP.

3.2.4 The current required for CP is much lower for coated steel tanks compared with bare or poorly coated steel tanks.

3.3 Uncoated Steel Tanks

3.3.1 It is feasible to design a CP system to provide complete protection for uncoated submerged surfaces of steel tanks (see Section 4).

3.3.2 It may be more practical to protect a bare or poorly coated steel tank with an impressed current system. This method is described in NACE Standard RP0388.[1]

3.4 Economic Considerations

3.4.1 For coated steel tanks, the cost of CP should be compared with the cost of recoating and metal loss. In addition to extending the life of existing coatings, CP reduces the need for recoating, repairs, leakage, and replacement caused by metal loss at holidays in the coating.

3.4.2 Metal loss can be reduced by the application of CP where the submerged surfaces are not coated or where the coating has deteriorated to the point that these surfaces can be considered uncoated. The cost of installing CP, projected maintenance costs, and monitoring costs should be compared with the cost of coating maintenance, metal loss, service disruption, reduction in tank life, and water quality degradation.

3.5 Operational Considerations

3.5.1 Removing the tank from service for coating maintenance or repairing corrosion damage can be eliminated or postponed if the CP system is designed and operated properly.

## Section 4: Design of Galvanic Anode CP Systems

4.1 General

4.1.1 The elements that the corrosion engineer must consider when designing galvanic anode CP systems for steel water storage tanks are outlined in this section.

4.1.2 In the design of a galvanic anode system, the following items must be considered:

(a) Health and safety,

(b) Compliance with local and national regulations,[3]

(c) Design of the tank (accessibility, crevices, shielded areas, baffles, and compartments),

(d) Present and future condition of the coating and the generic type of coating employed,

(e) Whether the water is subject to freezing,

(f) Driving voltage of various galvanic anode materials,

(g) Galvanic anode material, configuration, and circuit resistance,

(h) Galvanic anode life and ease of replacement,

(i) Ancillary equipment,

(j) Reference electrode location(s),

(k) Possibility of vandalism, and

(l) Water chemistry and temperature.

4.1.3 Whenever possible, the design should be based on standard galvanic anode shapes and sizes.

4.1.4 Selection of materials and system design shall strive to provide the best economic balance between the installation cost and the maintenance cost over the design life of the system.

4.2 Design Information

4.2.1 Before a galvanic anode CP system is designed, the following information should be obtained:

(a) Dimensions of the tank, including inlet/outlet columns, if any,

(b) Area of continuously and intermittently submerged steel surfaces,

(c) Flow patterns, recirculation, and the presence and design of internal heaters and baffling,

(d) Chemical analysis of the water and variation with seasons,

(e) Conductivity range, pH, and velocity of water,

(f) Frequency and rate of emptying and filling the tank,

(g) Type, condition, and age of internal coating system,

(h) Condition of internal steel surfaces exposed to the water,

(i) Whether the water is subject to freezing,

(j) Water temperature range, and

(k) Other pertinent information, including age and history of the tank, and whether the tank is of welded, bolted, or riveted construction.

4.2.2 In most cases, an on-site corrosion evaluation and preliminary design survey is useful.

## 4.3 Design Considerations

### 4.3.1 Current Output

4.3.1.1 The galvanic anode CP system must be capable of providing sufficient current to protect the tank to the minimum criterion for the full design life of the system, including any anticipated coating deterioration.

4.3.1.2 Calculated current output should be based on the current requirement for CP. This current requirement is expressed in terms of current per unit area of total submerged bare surface area, and depends on the corrosiveness of the water. In fresh waters, the current requirement is usually between 5 and 27 $mA/m^2$ (0.5 and 2.5 $mA/ft^2$) of submerged bare surface area. Installations involving high corrosion rates, nonpotable water, and galvanic metal couples may require considerably higher current densities.

4.3.1.3 The driving voltage used with the circuit resistance to calculate the current output shall be the difference between the open-circuit potential of the anode and the minimum polarized potential of the tank.

4.3.1.4 For circuit resistance calculations, refer to *Anode Resistance Fundamentals and Applications—Classic Papers and Reviews*.[4]

4.3.1.5 Circuit resistance variation as a result of temperature and water conductivity changes must be considered. Maximum circuit resistance shall be calculated based on the physical shape of the galvanic anode when it is 85% consumed.

### 4.3.2 Galvanic Anode Selection

4.3.2.1 Galvanic anodes shall be manufactured from magnesium (Mg) or zinc (Zn) alloys that are formulated specifically for this use. Table 1 lists typical galvanic anode materials and characteristics.

4.3.2.2 Galvanic anode materials shall be chosen to be compatible with the water composition and intended use.

4.3.2.3 All galvanic anodes shall have a steel core that extends throughout the full length of the anode and is centered in the galvanic anode, and on which the anode can be supported either vertically or horizontally.

### 4.3.3 Galvanic Anode Arrangement

4.3.3.1 Galvanic anodes shall be arranged to provide as close to uniform current density as is practical. When uniform current density cannot be achieved, the total system current output must be increased to compensate by adding anodes or adjusting the system current output through the test box described in Paragraph 4.3.4.1.

4.3.3.2 Galvanic anodes shall be suspended or mounted in such a way as to minimize damage to the system when ice conditions are anticipated or measures must be taken to prevent ice formation.

4.3.3.3 Galvanic anodes shall be installed and supported to prevent damage during high flow rates and when the tank is drained for inspection and cleaning.

4.3.3.4 Note: Some coatings have been damaged by excessive current density at coating holidays and excessive potential gradients across the coating. The coating selected shall be compatible with CP. Coating failures have been observed at polarized potentials more negative than -1,100 mV vs. saturated copper/copper sulfate reference electrode (CSE).

### 4.3.4 Installation, Monitoring, and Testing

4.3.4.1 One preferred method of installation is to use galvanic anodes with lead wires that connect to a collector (header) cable terminating in a test box with a tank connection cable, a tank test lead, a shunt, and a reference electrode lead. The use of a calibrated shunt between the anode collector cable and the tank connection cable facilitates measuring the current output of the system. The test box allows for interrupting and adjusting the current and obtaining a polarized potential vs. the reference electrode, free of IR drop. Although the other reference electrodes are sometimes used, CSE is preferred.

4.3.4.2 If the galvanic anodes are directly connected to the tank, a coupon and reference electrode shall be configured to evaluate the IR drop and approximate the polarized potential of the tank.[5]

### 4.3.5 Galvanic Anode Life

4.3.5.1 Galvanic anode life shall be calculated using the nominal operating current density.

4.3.5.2 Galvanic anode current capacities used in the system life calculations for any galvanic anode shall not exceed the consumption rate values given in Table 1.

4.3.5.3 The galvanic anode utilization factor when calculating life shall not exceed 85%.

**TABLE 1**
**TYPICAL GALVANIC ANODE MATERIALS AND CHARACTERISTICS**

| TYPE | ALLOY | NOMINAL CORROSION POTENTIAL[(A)] mV vs. CSE[(B)] | NOMINAL CONSUMPTION RATE[(C)] kg/A-yr |
|---|---|---|---|
| **Mg** | **ASTM[(D)] B 843[(E)]** | | |
| Mg/Mn | M1C | -1,750 | 8 |
| Mg/Al/Zn | AZ31B | -1,550 | 8 |
| Mg/Al/Zn | AZ63B | -1,550 | 8 |
| **Zn** | **ASTM B 418[(F)]** | | |
| Low Fe | Type II | -1,100 | 12 |

[(A)] Corrosion potential varies with water chemistry.
[(B)] CSE = Saturated copper/copper sulfate reference electrode.
[(C)] Consumption rate is dependent on water chemistry and anode current density.
[(D)] ASTM International, 100 Barr Harbor Dr., West Conshohocken, PA 19428-2959.
[(E)] ASTM B 843 (latest revision), "Standard Specification for Magnesium Alloy Anodes for Cathodic Protection" (West Conshohocken, PA: ASTM).
[(F)] ASTM B 418 (latest revision), "Standard Specification for Cast and Wrought Galvanic Zinc Anodes" (West Conshohocken, PA: ASTM).

4.3.6 Other

4.3.6.1 The preferred method of cable connection to the tank is by welding or thermite welding. If other connection methods, such as bolting, clamping, etc., are used, they must be secure. All electrical connections must be protected against corrosion.

4.3.6.2 All cable connections to the galvanic anodes shall be made to the core material by silver solder and subsequently coated.

4.3.6.3 All immersed cable-to-cable connections shall be made by high-strength compression connector or welding.

4.3.6.4 All cables located inside the tank shall be rated for use in submerged conditions.

4.3.6.5 For bolted and riveted tanks, electrical continuity of all joining components must be achieved if these components are to receive CP.

## Section 5: Installation of Galvanic Anode CP Systems

5.1 Introduction

5.1.1 This section outlines installation techniques for galvanic anode CP systems that protect water storage tanks when design considerations recommended in Section 4 have been followed.

5.2 Construction Specifications

5.2.1 All construction work on galvanic anode CP systems should be in accordance with construction drawings and specifications.

5.3 Construction Supervision

5.3.1 All construction work should be performed by, or under the direction of, a person who is qualified by experience in the installation of galvanic anode CP systems in water storage tanks, and who should verify that the installation is made in accordance with the drawings and specifications.

5.3.2 Deviations from construction documents and specifications shall be noted on as-built drawings and specifications.

5.4 Inspection and Handling

5.4.1 Galvanic anodes shall be inspected for conformance to specifications for correct galvanic anode material and size, length of lead wire, and method of wire connection. All wire and connections shall be carefully inspected for integrity. Damage to galvanic anode assemblies during handling and installation shall be avoided. If defects are not repaired, the anode must be rejected.

5.4.2 Stationary reference electrodes installed as part of the galvanic anode CP system shall be inspected and tested for conformance to the specifications. The stationary reference electrode shall be tested with reference to an accurate calibrated reference electrode in the electrolyte in which the stationary reference electrode is placed. If a difference in potential exists between the stationary and test reference electrode, the stationary electrode shall be replaced with one that matches the calibrated portable electrode to within ±10 mV.

5.5 Installation

5.5.1 Construction practices shall conform to all applicable local and national codes.

5.5.2 Test boxes shall be installed at a location for safe and convenient ground access.

5.5.3 All cables shall be protected from abrasion and sharp objects.

5.5.4 Short circuits shall not exist between the cables and the tank structure or conduit.

5.5.5 The preferred method of galvanic anode installation is to ensure that the anodes are electrically isolated from the tank, except through an accessible electrical connection that can be disconnected for testing of the system.

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## Section 6: Criteria for CP

6.1 Introduction

6.1.1 The purpose of this section is to list the criteria for CP, which, when complied with, either separately or collectively, indicate that adequate CP of submerged portions of steel water tank interiors has been achieved.

6.2 General

6.2.1 The objective of using galvanic anode CP is to control the corrosion of submerged portions of steel water tank interiors.

6.2.2 The selection of a particular criterion for achieving the objective in Paragraph 6.2.1 depends, in part, on prior experience with similar structures and environments wherein the criterion has been used successfully.

6.2.3 The criteria in Paragraph 6.3 were developed through laboratory experiment or were determined empirically by evaluating data obtained from successfully operated CP systems. It is not intended that persons responsible for corrosion control be limited to these criteria if it can be demonstrated by other means that the control of corrosion has been achieved.

6.2.4 Extended periods of time can be required to achieve polarization of uncoated or poorly coated tanks.

6.3 Criteria for Steel Water Tanks

6.3.1 A negative polarized tank-to-water potential of at least 850 mV relative to a CSE.

OR

6.3.2 A minimum of 100 mV of cathodic polarization between the structure surface and a stable reference electrode contacting the electrolyte. The formation or decay of polarization can be measured to satisfy this criterion.

CAUTIONARY NOTE: This criterion is only applicable to steel water tanks not having corrosion cells caused by connection to more noble metals such as copper, brass, or passive stainless steel (e.g., heated water tanks wherein the submerged heater tube is of copper or brass materials and is electrically continuous with the submerged metal of the tank).

6.4 Measurement Procedures

6.4.1 Potential measurements on water tank interiors should be made with the reference electrode located in the water (electrolyte) as close as possible to the tank steel surface. Consideration shall be given to voltage

(IR) drops other than those across the tank/water boundary, the presence of dissimilar metals, structural components, and other conditions that may interfere with valid interpretation of potential measurements.

6.4.2 In order to observe the polarized tank-to-water potential, the IR drop shall be eliminated from the measurement. Among the methods used to eliminate IR drop are (1) measuring the tank-to-water potential with the protective current instantaneously interrupted and (2) interrupting the electrical connection between the tank and a submerged coupon(s) and immediately measuring the tank-to-water potential of the coupon.

6.4.3 A sufficient number of potential measurements shall be taken to determine that adequate protection is being achieved throughout the steel tank, especially at the most difficult-to-protect locations. In practice, potential profiles of the submerged steel at intervals along the wall and floor during initial adjustment shall be taken.

6.5 Alternative Reference Electrodes

6.5.1 While CSE is the standard reference electrode for use in water storage tanks, other reference electrodes that may be substituted for CSE are listed below along with their potential equivalent to -850 mV vs. a CSE.

(a) vs. Zn: +250 mV, and

(b) vs. saturated silver/silver chloride electrode: -735 mV.

Regular calibration of reference electrodes is recommended.

6.6 Special Considerations

6.6.1 Abnormal conditions in which protection is ineffective or only partially effective sometimes exist. Such conditions include elevated temperatures, disbonded coatings, shielding, bacterial attack, and unusual contaminants in the water.

## Section 7: Operation and Maintenance

7.1 This section covers the procedures necessary for the operation and maintenance of an effective galvanic anode CP system.

7.2 Operation

7.2.1 After the system has been allowed to reach a stable polarization level, the system shall be tested and adjusted to obtain the potentials indicated in Paragraph 6.3.

7.2.2 For a galvanic anode CP system to control corrosion effectively, it must be kept in continuous operation and provide the desired tank-to-water potential.

7.3 Maintenance

7.3.1 Maintenance should be conducted under the direction of qualified personnel as described in Paragraph 1.8 of this standard.

7.3.2 Annual Testing

7.3.2.1 Under normal conditions, testing of galvanic anode systems shall be performed annually. This frequency could vary depending on changes in parameters listed in Paragraph 4.2.1.

7.3.2.2 Tests shall be conducted to determine whether the criteria set forth in Paragraph 6.3 are being achieved. The potential and current output shall be monitored and the circuit resistance adjusted so that the criteria in Paragraph 6.3 are achieved.

7.3.2.3 Reference Electrodes

7.3.2.3.1 With current off, stationary reference electrodes installed in the tank should be compared with a recently calibrated portable electrode of identical composition to ensure proper levels of protection. If it is not possible to interrupt the current, the stationary reference electrode shall be removed from the tank and tested in a nonmetallic container. The two reference electrodes should have a potential difference of less than ±10 mV. When the potential difference exceeds ±20 mV, the stationary electrode shall be replaced.

7.3.2.3.2 Placement of the stationary reference electrode in the tank shall be evaluated to determine whether it corresponds to the most representative of portable reference electrode potentials of the tank. Readings made with a portable reference electrode moved to several different locations shall be compared with readings from the stationary reference electrode to ensure the stationary reference electrode values are representative of the entire tank.

7.3.2.3.3 For installations in which a stationary reference electrode is not installed or is not functioning, a calibrated portable reference electrode shall be used to take readings at several locations in the tank.

7.3.2.4 Annual Inspections

7.3.2.4.1 All galvanic anode CP system components should be completely inspected annually. The inspection shall include polarized potential measurements—corrected for IR drop by either interruption of the anode current or the coupon connection to the tank—to ensure that the system is operating properly. For tanks with handholes in the top, this includes lowering a portable reference electrode into the tank and taking instant-off measurements along the tank wall to evaluate whether all surfaces of the tank are protected. When instant-off measurements are not possible, the coupon data or some other method shall be used to correct for IR drop. The connection to the portable reference electrode and all the metal components on the electrode and the wire shall be completely insulated.

7.4 Anode Replacement

7.4.1 All galvanic anodes that have ceased to function properly should be replaced. Tank-to-water potentials, current output, and/or visual inspections shall be used to evaluate anode performance.

7.4.2 Damaged or deteriorated cables, anode lead wires, and electrical connections shall be replaced or repaired using specific system components compatible with the original design.

7.4.3 In tanks subject to icing conditions, galvanic anodes shall be inspected and/or tested after the probability for freezing has passed. Damaged anodes shall be replaced.

7.4.4 When the water storage tank is taken out of service, the galvanic anodes should be examined and broken or damaged anodes shall be replaced.

7.4.5 Galvanic anodes should also be examined to determine consumption. When galvanic anode remaining life is less than the time to the next inspection, anodes should be scheduled for replacement.

7.5 Records

7.5.1 Tank Information

7.5.1.1 Complete information and the history of the tank itself should be recorded, including:

(a) Dimensions and capacity,

(b) Tank erection and CP contractor,

(c) Date of erection,

(d) Coupon type, configuration, and location,

(e) Original coating, including system, surface preparation, and materials,

(f) Subsequent coatings and dates of coating,

(g) History of any structural repairs,

(h) Costs associated with maintenance of the tank,

(i) Tank location,

(j) Warranty dates on coatings and CP, and

(k) Water temperature range.

7.5.2 Water Information

7.5.2.1 Complete information about the water stored in the tank should be recorded. This information includes both the chemical and electrical characteristics, as well as information about the variations in these characteristics that occur throughout the year. If different sources of water that have substantially different resistances are used, the frequency of maintenance testing may need to be adjusted so that tests are conducted at each time a change in water chemistry occurs. Basic to determining the changes in chemistry would be the resistivity of the water, which can also be reflected by the total dissolved solids in the water.

7.5.2.2 Operational information about frequency of draining, cleaning, and filling should be recorded.

7.5.3 CP

7.5.3.1 Complete information about the installation and design of the galvanic anode CP system should be documented, including:

(a) The number and configuration of galvanic anodes,

(b) Galvanic anode dimensions and typical composition,

(c) Stationary reference electrode type, model number, and manufacturer,

(d) Wiring and anode suspension,

(e) Electrical schematic diagrams,

(f) Individual galvanic anode circuits and shunt resistances,

(g) Test box with shutoff switch, and

(h) Date of energizing and initial current and potential readings.

7.5.3.2 Maintenance records that include the following should be kept:

(a) Tabulation of annual measurements of galvanic anode output voltage and current and tank-to-water potentials. These measurements should be taken when the tank is relatively full. The water surface elevation should be recorded each time potential measurements are taken. The location of potential measurements should be recorded.

(b) Reports on annual inspections.

(c) All repairs and additions to the galvanic anode CP systems.

(d) Costs of maintenance including coating, CP inspections, etc.

## References

1. NACE Standard RP0388 (latest revision), "Impressed Current Cathodic Protection of Internal Submerged Surfaces of Carbon Steel Water Storage Tanks" (Houston, TX: NACE).

2. J.B. Bushman, D.H. Kroon, "Cathodic Protection of Water Storage Tanks," AWWA[(1)] Journal 76, 1 (1984).

3. ANSI[(2)]/NSF[(3)] 61, "Drinking Water System Components—Health Effects" (Ann Arbor, MI: NSF International).

4. R.L. Benedict, ed., Anode Resistance Fundamentals and Applications—Classic Papers and Reviews (Houston, TX: NACE, 1986).

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[(1)] American Water Works Association (AWWA), 6666 W. Quincy Avenue, Denver, CO 80235.

[(2)] American National Standards Institute (ANSI), 1819 L Street NW, Washington, DC 20036.

[(3)] NSF International (NSF), P.O. Box 130140, 789 Dixboro Road, Ann Arbor, MI 48113-0140.