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Standard
Recommended Practice

Impressed Current Cathodic Protection of Internal Submerged Surfaces of Carbon Steel Water Storage Tanks

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NACE International
1440 South Creek Drive
Houston, Texas 77084-4906
+1 281/228-6200

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Foreword

The purpose of this NACE standard is to present the recommended practices for providing impressed current cathodic protection (CP) to the normally submerged steel surfaces inside water storage tanks. It contains recommendations for the design and installation of these cathodic protection systems and methods for determining the effectiveness of these systems. Recommendations for the operation and maintenance of both automatic and manual systems are also provided. This standard is applicable to relatively large water storage tanks used in municipal water supply and fire protection, including elevated and on-grade tanks. Although the general principles outlined in this standard are applicable to all such tanks, the impressed current cathodic protection system described in this standard may not be practical for smaller tanks. This standard is intended for use by engineers, water utilities, tank erectors and other contractors, and owner operators of steel water storage tanks.

This standard was originally prepared in 1988 by Task Group T-7L-1, a component of Unit Committee T-7L on Cathodic Protection. The task group was composed of corrosion engineers and others experienced in the design, installation, and maintenance of impressed current cathodic protection systems for water storage tanks. It was reaffirmed by T-7L in 1990, 1995, and revised in 2001 by Task Group 167 (formerly T-7L-14). Task Group 167 is administered by Specific Technology Group (STG) 05 on Cathodic/Anodic Protection. It is issued by NACE International 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.

NACE International
Standard
Recommended Practice

Impressed Current Cathodic Protection of Internal Submerged Surfaces of Steel Water Storage Tanks

Contents

Section 1: General

1.1 This standard presents recommended practices for applying impressed current cathodic protection to the internal submerged surfaces of steel tanks used for the storage of natural waters. These tanks may be provided with an interior barrier coating. It is not intended for use with metallic coatings or linings, such as zinc or aluminum.

1.2 It is recognized that galvanic anode systems can, at times, be used for cathodic protection of the internal surfaces of water storage tanks; however, this standard addresses only impressed current systems.

NOTE: Information regarding galvanic cathodic protection of water storage tanks may be found in RP0196,"Galvanic Anode Cathodic Protection of Internal Submerged Surfaces of Steel Water Storage Tanks."[1]

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

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 Cathodic protection, as described in this standard, may be used alone to control corrosion of submerged steel surfaces or used as a complement to the protection afforded by protective coatings. Cathodic protection cannot protect surfaces that are not submerged. These surfaces must be protected by coatings alone. Cathodic protection does not reverse structural damage already caused by corrosion.

1.6 Cathodic protection may be installed to control corrosion in both newly constructed and existing tanks. When cathodic protection is used on existing tanks, it is not necessary to prepare the surfaces to be protected; however, 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, which may be subject to public health and safety regulations. This standard should not infringe upon those regulations. Proper disinfection of the tanks may be required after installation. Any applicable regulations such as those from the U.S. Environmental Protection Agency (EPA)[(1)] and ANSI[(2)]/NSF[(3)] -612 should be checked. In the United States, all materials in contact with potable water or exposed to the interior of potable water tanks must be classified in accordance with ANSI/NSF-61.

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 and cathodic protection for water storage tanks. Such persons may be registered professional engineers or persons certified by NACE International as Cathodic Protection or Corrosion Specialists, if their professional activities include suitable experience in corrosion control and cathodic protection.

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

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.

Calcareous Coating: A layer consisting of calcium carbonate and other salts deposited on the surface. When the surface is cathodically polarized as in cathodic protection, 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 Disbondment: The destruction of adhesion between a coating and the coated surface caused by products of a cathodic reaction.

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

(1) U.S. Environmental Protection Agency (EPA), 401 M Street SW, Washington, DC 20460.
(2) American National Standards Institute (ANSI), 11 W 42nd St, New York, NY 10036.
(3) NSF International, P.O. Box 130140, Ann Arbor, MI 48113-0140.

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: A measure of the ability of a material to carry an electric current. In water, this depends on the total concentration of the ionized substances dissolved and the temperature at which the measurement is made. It is the reciprocal of resistivity and is usually expressed in µS/cm (µmhos/cm).

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.

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 purposes 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 cathodic protection.

Holiday: A discontinuity in a protective coating that exposes unprotected surface to the environment.

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 cathodic protection.)

Impressed Current Anode: An anode, usually composed of substantially inert materials, that is supplied with impressed current.

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.

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: A measure of the specific resistance of a material to the passage of electric current. It is usually expressed in ohm-centimeters (ohm-cm) and is the reciprocal of conductivity.

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

Section 3: Determination of the Need for Cathodic Protection

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 hydraulic and aesthetic effects of corrosion debris in the tank and piping.

3.1.2 All coatings are subject to damage and deterioration. Therefore, corrosion control by use of coatings alone on the submerged surfaces of a steel water storage tank is usually not possible.

3.1.3 Cathodic protection is effective in controlling corrosion only on the submerged metal surfaces.

3.2 Cathodic Protection of Coated Tanks

3.2.1. In almost all cases, natural waters are sufficiently corrosive to require the use of protective coatings and cathodic protection for corrosion control. Protective coatings and cathodic protection are synergistic with the combination of the two methods, providing a greater degree of corrosion protection than either method used alone.

3.2.2. Properly designed and maintained, cathodic protection systems can extend the useful life of the water tank and its coating system.

3.2.3 The current required for cathodic protection is lowered significantly when coatings are also used.

3.2.4 The coating system should be compatible with cathodic protection.

3.3 Cathodic Protection of Uncoated Steel Tanks

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

3.3.2 For existing steel tanks with submerged surfaces that are not coated or that have coatings in poor condition, it may be economical to rely entirely on cathodic protection.

3.4 Economic Considerations

3.4.1 Coated Tanks

The cost of cathodic protection should be compared with the cost of recoating and metal loss. Cathodic protection defers the need for coating repair and recoating for considerable time. This effectively extends the life of the coating system. In addition, cathodic protection prevents repair costs from metal loss.

3.4.2 Uncoated Tanks

It is possible to prevent metal loss in steel tanks where the surfaces are not coated or where the coating has deteriorated to the point that the surfaces can be considered uncoated. The cost of cathodic protection should be compared with the cost of metal loss, service disruption, reduction in design life, and water quality degradation.

3.5 Operational Considerations

3.5.1 Taking the tank out of service for coating maintenance or corrosion repair can be eliminated or postponed if the cathodic protection system is designed and operated properly.

3.5.2 Two benefits of keeping the tank in continuous service are system capacity and water availability for fire protection.

Section 4: Design of Impressed Current Cathodic Protection Systems

4.1 Introduction

4.1.1 This section outlines the elements that should be considered when designing impressed current cathodic protection systems for steel water storage tanks.

4.1.2 In the design of an impressed current system, the following items must be considered:

(a) Design of the tank (accessibility, crevices, shielded areas),
(b) Present and future condition of the coating and the generic type of coating employed,
(c) Voltage and current capacity of the power source,
(d) Impressed current anode material and configuration,
(e) Impressed current anode life and ease of replacement,
(f) Type of power source control,
(g) Hardware,
(h) Reference cell location(s),
(i) Power costs,
(j) Possible evolution of hydrogen and ventilation requirements,
(k) Possibility of vandalism, and
(l) Compliance with ANSI/NSF-61[2] in the U.S., or other governing standards outside the U.S.

4.1.3 Whenever possible, the design should be based on standard components provided by manufacturers regularly engaged in the production of impressed current cathodic protection systems for steel water storage tanks.

4.1.4 Selection of materials and system design should be accomplished in a manner to provide the best economic balance between the installation cost, the maintenance cost, and the electrical power cost over the design life of the system.

4.2 Information Required

4.2.1 Before undertaking the design of an impressed current cathodic protection system, the following information about the tank should be obtained:

(a) Dimensions of tank, including riser if tank is elevated,
(b) Area of submerged steel surfaces (including ladders, baffles, braces, struts, etc.),
(c) Chemical analysis of water,
(d) Water conductivity,
(e) Seasonal variation in water composition,
(f) Frequency and rate of emptying and filling the tank,
(g) Type, specification and condition of internal coating,
(h) Condition of internal steel surfaces exposed to the water,
(i) Whether or not water is subject to freezing,
(j) Average and extreme water temperatures,
(k) Cost and availability of alternating current (AC) power,
(l) Flow patterns, recirculation, aerators, heaters, riser pipes, and
(m) Other pertinent information, including age and history of tank; and whether the tank is of welded, bolted, or riveted construction; and area classification.

NOTE: For bolted and riveted tanks, electrical continuity of all joining components must be ensured if corrosion control of these components by impressed current cathodic protection is to be achieved.

4.2.2 For existing tanks, an on-site corrosion evaluation, current requirement test, performance of systems in similar service, and/or laboratory testing to determine polarization characteristics may be useful.

4.3 Direct Current (DC) Power Source

4.3.1 Impressed current cathodic protection requires DC power. It is commonly obtained from transformer-rectifier units that step down AC power and convert it to DC power. However, DC power may be available from other sources such as solar cells. Units should be designed and manufactured to provide continuous, dependable operation for 10 to 20 years. Proper protective and monitoring devices, including disconnect switches; circuit breakers; output voltmeters; ammeters; and surge, lightning, and overload protection should be provided. Units should be either manually or automatically controlled over the full voltage output range.

4.3.2 Output Current Capacity

4.3.2.1 Current capacity of the unit should be based on the current requirement for cathodic protection. 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). Installations involving high corrosion rates, nonpotable water, and galvanic metal couples may require considerably higher current densities.

4.3.2.2 Coating the steel tank surface reduces the total current required in proportion to the effectiveness of the coating coverage. On newly coated tanks, the initial current requirement may be less than 1% of the requirement of an uncoated surface under the same conditions.

4.3.2.3 Current capacity for a coated tank should be selected so that there is sufficient capacity available even after considerable coating deterioration, typically 10 to 20% for a 20-year system design life.

4.3.3 Output Voltage Capacity

4.3.3.1 The output voltage capacity is governed by the current requirement and the circuit resistance. The voltage capacity shall be selected to overcome the wire resistance and highest anticipated anode-to-water resistance at the total current demand needed for the life of the system.

4.3.3.2 Power requirements are directly related to voltage as well as current. Therefore, operating voltage should be as low as possible (consistent with other economic considerations) and yet high enough to maintain the current required for protection.

4.3.4 Multiple-Circuit Systems

4.3.4.1 A separately controlled circuit should be provided for energizing other circuits, such as the riser anode assembly, if necessary.

4.3.4.2 Other applications for multiple system circuits might include unusual geometries, tanks with baffles, etc.

4.4 Impressed Current Anodes

4.4.1 Impressed Current Anode Configuration

4.4.1.1 Impressed current anodes shall be arranged in the tank so that protection can be provided to all surfaces without exceeding potentials (in the vicinity of the anodes) that will be detrimental to the coating system.

4.4.1.2 The number, diameter, and length of impressed current anodes shall be sufficient to achieve an acceptable circuit resistance and proper current distribution.

4.4.1.3 The design shall prevent shorting of impressed current anodes to the tank surfaces. This is particularly important in elevated tank riser pipes.

4.4.1.4 Where freezing occurs, provisions should be made for periodic replacement or for an impressed current anode installation unaffected by either freezing or falling ice. Alternatively, the tank may be operated in a manner to prevent ice accumulation on the anodes or in a solid mass across the tank, which could damage the anodes when collapsing.

4.4.2 Impressed Current Anode Materials

4.4.2.1 In designs in which only one year of anode life is required, anode materials such as aluminum alloy UNS[(4)] A92017 may be used.

4.4.2.2 Impressed current anodes whose service life must exceed one year should be composed of more permanent material, such as mixed metal oxide-coated titanium, platinized titanium or niobium, or high-silicon cast iron. The material should be selected for its suitability in the service environment. Anode materials used in nonpotable water service may be different from those used in potable water.

4.4.2.3 Impressed current anodes, as well as all cathodic protection equipment to be installed in the tank, shall be chosen such that there is no contamination of potable water. Refer to ANSI/NSF-61[2] requirements.

4.4.3 Impressed Current Anode Life

The impressed current anode life depends on the consumption rate of the material selected, the weight of that material, and the current output of the system. In the case of mixed-metal oxide coated anodes, the life is dependent on the current density rating of the coating. The design should reflect the desired anode life in the specific electrolyte.

4.5 Hardware

4.5.1 All impressed current anode support hardware and wiring should be selected for maximum economical life for the conditions inside the steel tank.

4.5.2 For vertically suspended impressed current anode systems, hand holes or mounting devices should be provided so that the anodes can be serviced without entering the tank. Any hand holes should have suitably designed weatherproof covers.

4.5.3 Horizontally oriented impressed current anode systems located below the normal water level do not normally require hand holes but may require drainage of the tank for servicing.

4.5.4 All wiring on the outside of the steel tank shall be in rigid conduit and installed with applicable codes. The use of conduit for insulated impressed current anode wiring inside the tank is not necessary.

4.5.5 Permanent reference electrodes lead wire should be brought to the rectifier location to facilitate readings. Reference cell wiring shall not be routed through the same conduit used for system DC wiring.

Section 5: Installation of Impressed Current Cathodic Protection Systems

5.1 Introduction

This section outlines installation techniques for water storage tank impressed current cathodic protection systems that protect the structure when design recommendations in Section 4 have been followed.

5.2 Construction Specifications

All construction work on impressed current cathodic protection systems shall be done in accordance with construction drawings and specifications. The drawings and specifications should be prepared by a qualified corrosion engineer, in accordance with the recommended procedures in Sections 1 and 4, and any other applicable codes. If changes are necessary, they shall be approved in writing by the engineer or owner.

5.3 Construction Supervision

5.3.1 All construction work should be performed by or under the direction of a person who is trained and qualified in the installation of impressed current cathodic protection systems in water storage tanks, and who shall verify that the installation is made in strict accordance with the drawings and specifications. Exceptions may be made only with the consent of the corrosion engineer when it can be demonstrated that the effectiveness of the system will not be impaired.

5.3.2 All deviations from original design shall be noted on record drawings.

[(4)] Metals and Alloys in the Unified Numbering System (latest revision), a joint publication of the American Society for Testing and Materials (ASTM), 100 Barr Harbor Drive, West Conshohocken, PA 19428, and the American Society of Automotive Engineers Inc. (SAE), 400 Commonwealth Drive, Warrendale, PA 15096.

5.4 Inspection and Handling

5.4.1 The DC power source shall be inspected to ensure that internal connections are mechanically secure and that no damage is apparent. Rating of the DC power source shall comply with Paragraph 4.3.1 and the construction specifications.

5.4.2 Impressed current anodes shall be inspected for conformance to specifications for correct anode material and size, length of lead wire, method of wire connection, and damage to any portion of the assembly. Damage to anodes during handling and installation must be avoided. All wire should be carefully inspected for insulation defects, and damage to insulation must be avoided. If defects are not repaired, the anode must be rejected. Damage to insulation may result in premature failure of the wire.

5.5 Installation

5.5.1 The power supply should be installed so that the possibility of damage or vandalism is minimized.

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

5.5.3 All power sources which provide AC service to a CP system should have a disconnect built into the equipment and shall also have a separate, external disconnect. Dedicated AC service will allow the equipment to be isolated for maintenance and lockout.

5.5.4 The power supply should be installed at a convenient height above the ground so that it may be serviced readily unless other factors such as vandalism, flooding, etc., apply.

5.5.5 The positive cable and anode leads are especially critical to the operation of the system. It is imperative that insulation remains intact. The entire cable and all connections must be waterproof. The cable must be protected from abrasion and sharp objects. There shall be no metal-to-metal contact between the positive cable and the tank structure or conduit. The positive cable(s) must be connected to the impressed current anodes, and the negative cable(s) must be properly connected to the tank.

5.5.6 Underwater splices on the positive cable should be avoided unless required by in-service installation or repairs to the system. Connections between the positive cable and anode leads must be mechanically secure and electrically conductive. These connections must be sealed to prevent moisture penetration.

Section 6: Criteria for Cathodic Protection and Measurement Procedures

6.1 Introduction

6.1.1 This section describes the criteria for impressed current cathodic protection along with measurement techniques which, when followed, provide virtually complete corrosion control on the internal, submerged surfaces of steel water storage tanks.

6.1.2 The criteria in Paragraph 6.2 have been developed through laboratory experiments and have been verified by evaluating data obtained from successfully operated impressed current cathodic protection systems. It is not intended that the corrosion engineer be limited to these criteria if it can be demonstrated that corrosion control can be otherwise achieved.

6.1.3 Measurement of the voltage between the tank and a reference electrode placed in the water shall be used to determine whether adequate cathodic protection has been achieved. This voltage is referred to as tank-to-water potential.

6.2 Criteria

6.2.1 A negative, polarized tank-to-water potential of at least -850 mV relative to a saturated copper/copper sulfate reference electrode (CSE); or

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

CAUTIONARY NOTE: The 100 mV polarization shift 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 in which the submerged heater tubes are constructed of copper or brass, and are electrically continuous with the submerged steel tank).

6.3 Measurement Procedures

6.3.1 In order to observe the polarized tank-to-water potential, the IR drop error must be eliminated from the measurement. Among the methods used to eliminate IR drop error 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 coupon-to-water potential.

6.3.2 A sufficient number of potential measurements should 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 should be taken.

6.3.3 A reference electrode other than a CSE may be used. The potential representing the minimum protective value shall be equivalent to the -850 mV value for the CSE. For example, when a saturated potassium chloride (KCl) calomel reference is used, the appropriate value is -780 mV.

6.4 Cautionary Note

NOTE: Cathodic protection for well-coated tanks should only be designed, installed, and energized under the direction of a corrosion engineer with coating and cathodic protection experience. The coating system must be compatible with cathodic protection and must demonstrate resistance to cathodic disbondment. It has been observed that some coatings may not be compatible with cathodic protection and may be damaged by excessive currents. While there is currently no agreement regarding the tank-to-water potential at which damage occurs, coating failures have been observed at polarized potentials more negative than -1.1 V to a CSE.

The cathodic protection system should be energized as soon as possible after the tank is filled with water. Waiting until the coating warranty period has expired only subjects the tank to additional deterioration from corrosion and may lead to severe pitting attack at holidays in the coating.

Section 7: Automatic Impressed Current Systems

7.1 Introduction

7.1.1 This section describes practices for the automatic regulation of cathodic protection current to maintain a pre-selected tank-to-water potential. The pre-selected tank-to-water potential should be in accordance with Section 6.

7.1.2 The use of manually controlled cathodic protection systems is acceptable and may be desirable depending on specific structure conditions as determined by the design corrosion engineer.

7.2 General

7.2.1 Cathodic protection current requirements for protection in accordance with the criteria in Paragraph 6.2 can vary with coating deterioration, accumulation of polarization films, temperature, water level, water velocity, water composition, dissolved oxygen, and other conditions. If the proper tank-to-water potential is maintained, the effectiveness of corrosion control is assured.

7.2.2 Automatic cathodic protection systems are designed to adjust the current output so that the tank-to-water potential remains at a preset constant value required for effective corrosion control. For some impressed current anode configurations, automatic cathodic protection systems may be necessary. Consideration should be given to providing current-limiting devices to prevent excessive current outputs that may be harmful to the coating (see Paragraph 6.4).

7.3 Components

7.3.1 Power Source Unit

7.3.1.1 The power source used to energize the cathodic protection system shall be capable of varying the current output from 0 to 100% of its rated capacity.

7.3.1.2 The tank-to-water potential used to control the current output shall be derived from a reference electrode or electrodes properly placed in the water tank.

7.3.1.3 The tank-to-water potential used to control the current output shall be consistent with the criteria given in Paragraph 6.2.

7.3.1.4 The power source shall be capable of varying the current output in order to maintain the tank-to-water potential within ±25 mV of the selected value.

7.3.2 Reference Electrode(s)

The reference electrode(s), from which the tank-to-water potential is obtained for controlling the current output, must be continually immersed. The reference electrode(s) should have a potential difference of less than ±10 mV when compared with a new electrode. When the potential difference exceeds ±20 mV, the electrode shall be replaced.

Section 8: Operation and Maintenance

8.1 This section outlines the procedures necessary for the effective operation and maintenance of impressed current cathodic protection systems.

8.2 Operation

8.2.1 For an impressed current cathodic protection system to control corrosion effectively, it must be kept in continuous operation and maintain a level of protection that satisfies the criteria.

8.2.2 When the system is energized, it shall be adjusted to obtain the desired tank-to-water potential in accordance with Paragraph 6.2.

8.3 Maintenance

8.3.1 Monthly

8.3.1.1 The power unit should be inspected at least once each month to verify that it is operating correctly and that the proper tank-to-water potentials are being maintained.

8.3.1.2 In a manually controlled system, the voltage and current of the power unit and the tank-to-water potential using permanent reference electrodes, if any, shall be measured. If the tank-to-water potential is outside the proper range, the cause shall be determined and adjustments made accordingly.

8.3.1.3 In an automatic system, the tank-to-water potential shall be measured to determine that the system is maintaining the predetermined potential within the tolerance indicated in Paragraph 7.3.1.4. A log shall be maintained to establish an operating profile and shall be referred to when making regular inspections. If the potential is outside the proper range, the cause shall be determined. Among the possible causes of potential drift are wiring faults exceeding the current capacity of the unit or a defective reference electrode. Among the possible causes of a change in current are defective reference electrode, wiring faults, establishment of calcareous deposits, and coating deterioration. The first two require immediate replacement or repair. The third normally requires a decrease and the fourth, an increase, in current requirement.

8.3.1.4 More frequent inspection of the systems may be desirable in critically corrosive situations, when the tank has previously suffered extensive metal loss as a result of corrosion or when there are highly variable conditions.

8.3.1.5 Remote monitoring equipment can aid in the collection of the data, reduce monitoring costs, and allow for more frequent, real-time data collection during a variety of tank operations, such as filling and sudden drops in water level.

8.3.2 Annual

8.3.2.1 All impressed current cathodic protection system components should be completely inspected annually. This inspection should include potential profile testing with portable instruments to ensure that the system is operating properly. The power source, controls, anodes, wiring, and reference electrodes should be examined and replaced as required.

8.3.2.2 Power Source—The power unit is usually designed for long life with little maintenance required. The monthly inspection indicated in Paragraph 8.3.1.1 should reveal any failures requiring repairs and replacements. Annual maintenance should include removing debris at the openings required for cooling, checking that all connections and wiring are secure and unaffected by corrosion, inspecting the electrical grounding, and painting of cabinets and housings, if required.

8.3.2.3 Impressed Current Anodes and Wiring

8.3.2.3.1 In systems using impressed current anodes designed for one-year life (see Paragraph 4.4.2.1), all anodes shall be replaced annually (or according to design life). In water storage tanks subject to icing conditions, anodes should be replaced in the spring after the opportunity for freezing has passed. Alternatively, the tank may be operated in a manner to raise and lower the water level during freezing conditions and thereby extend anode life.

8.3.2.3.2 Lowering the water level provides an opportunity to inspect the interior surface of the tank. If the tank is coated, the condition of the coating should be recorded. Also, the presence of either corrosion or calcareous deposits should be recorded.

8.3.2.4 Reference Electrodes

8.3.2.4.1 Reference electrodes and connecting wire should be inspected to determine whether they are physically capable of operating until the next annual inspection. Any breaks in the wiring insulation must be repaired. If insulation has deteriorated, wiring shall be replaced. It is important that all wiring and connections to reference electrodes be completely insulated.

8.4 Records

8.4.1 Tank Information

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

(a) Dimensions, configuration, and capacity,
(b) Tank contractor,
(c) Date of erection,
(d) Materials of construction,
(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 erection and maintenance of the tank,
(i) Tank location, and
(j) Warranty dates on coatings and cathodic protection.

8.4.2 Water Information

8.4.2.1 Complete information about the water stored in the tank should be recorded. This information should include both the chemical and electrical characteristics as well as information about variations in these characteristics that occur throughout the year as a result of natural causes, disinfection, and water treatment.

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

8.4.3 Cathodic Protection System

8.4.3.1 Complete information about the installation and design should be recorded, including:

(a) Power source capacity, both AC and DC,
(b) Number and configuration of impressed current anodes,
(c) Impressed current anode material and design life,
(d) Wiring and anode suspension,
(e) Electrical schematic diagrams, and
(f) Date of energizing and initial current and voltage settings.

8.4.3.2 Maintenance records should be kept, including:

(a) Tabulation of monthly measurements of impressed current voltage and current of the power source and tank-to-water potentials. Water surface elevations at the time of testing should also be recorded.
(b) Reports of annual inspections.
(c) All repairs and additions.
(d) The cost of all maintenance, including coating, cathodic protection inspection, etc.

References

1. NACE Standard RP0196 (latest revision), "Galvanic Anode Cathodic Protection of Internal Submerged Surfaces of Steel Water Storage Tanks" (Houston, TX: NACE).

2. NSF-61 (latest revision), "Drinking Water System Components" (Ann Arbor, MI: NSF International).