GENERIC
OPERATION AND MAINTENANCE PROCEDURES
SACRIFICIAL ANODE
CATHODIC PROTECTION SYSTEM

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I. INTRODUCTION

The owner is required to perform periodic operational checks for any sacrificial anode cathodic protection (CP) system. Annual maintenance inspections are also recommended to ensure that the long-term effectiveness of the system continues over its intended design life. This document provides a brief summary of the monitoring and maintenance procedures that the owner must perform to allow the CP system to provide the highest degree of effectiveness in mitigating corrosion.

II. CATHODIC PROTECTION THEORY

Although there are numerous forms of metallic corrosion, there are two basic mechanisms for corrosion of metallic structures. These mechanisms are known as galvanic and electrolytic corrosion. In either mechanism, the corrosion cell consists of four main components that *must* be in place for corrosion to occur:

- Anode – Area where corrosion (metal loss) occurs.
- Cathode – Area where metal does not corrode (metal is protected).
- Electrolyte – Environment into which the metal is placed (soil, water, concrete).
- Metallic Circuit – An electrical connection between the anode and the cathode.

Galvanic Corrosion

Galvanic corrosion is a natural process that results from the differences in electrical potential energy along a surface of a metal. These electrical potential differences can be caused by the coupling of dissimilar metals (bi-metallic corrosion). Non-homogeneity in the metallurgy of the structure or variations in the electrolyte (concentration cells) that exist along a metal's surface can also cause galvanic corrosion. The process occurs when two dissimilar metals are electrically connected *and* are contained within a conductive electrolyte. One of the metals (the anode) will corrode, and will provide a source of DC current to the other non-corroding metal (the cathode). The current flow is from the anode into the conductive electrolyte and onto the cathode. The anode-cathode metallic connection completes the circuit and allows the corrosion reaction to proceed.

Electrolytic Corrosion

Electrolytic corrosion (sometimes called stray current corrosion) is caused by DC current flow on a metallic structure. The current is often the result of man-made DC ground voltages that result from foreign sources such as DC-powered transit systems, high voltage DC power transmission lines, electroplating processes, and welding operations. If a metallic structure intersects these DC ground voltage gradients, differing energy levels will be introduced along the structure. Where DC current is picked up on the structure from the surrounding electrolyte, the structure will receive a *degree* of cathodic protection, if the current is not too high to degrade the metallurgy of the metal. However, where DC current is discharged from the metal into the electrolyte, the structure will corrode and metal loss will occur. The degree of corrosion damage is directly proportional to the magnitude of current flow from the structure.

Corrosion Mitigation by Cathodic Protection

Cathodic protection is an electrochemical means of corrosion mitigation that minimizes the anodic dissolution of a metallic structure by reducing the electrical potential energy *difference* between the anodic and cathodic sites on a metal's surface when placed into a conductive electrolyte. Theoretically, cathodic protection is achieved when the open circuit potentials of the cathodic sites are *polarized* to the open circuit potentials of the anodic sites. The goal is to make the entire structure a cathode (current receiver) relative to an expendable or replaceable anode (current provider). Specific criteria have been established by the National Association of Corrosion Engineers (NACE) for various metals in different electrolytes. The corrosion engineer must carefully consider these criteria when deciding on the level of cathodic protection to apply to a metallic structure.

There are two basic methods of applying cathodic protection, although there are many variations on installing cathodic protection. These two methods are known as sacrificial (galvanic) anodes and impressed current (rectifier) cathodic protection.

Sacrificial Anode Cathodic Protection

Sacrificial anodes are usually made of an alloy of magnesium or zinc for underground service. Each type of sacrificial anode will provide a source of cathodic protection current due to the anode's higher electrical potential energy than the structure intended for protection based upon the Practical Galvanic Series. The size and shape of the anode, the structure's coating, and the intended design life of the system are additional factors that must be considered.

Impressed Current Cathodic Protection

An impressed current cathodic protection system uses inert anodes that are powered by an external source of DC current which is typically a rectifier-transformer. Anodes can be materials such as graphite, cast iron, and mixed-metal oxide-coated titanium. Many sizes and shapes of impressed current anodes are available including wire, rods, tubes, sticks, plates, and disks. The composition of the electrolyte is very important when selecting an impressed current anode. In this type of system, the anodes are installed within the structure's electrolyte and are connected to the positive output terminal of the rectifier. The structure is connected to the rectifier's negative output terminal. Current flow is from the anodes through the electrolyte and onto the structure. The metallic connection from the structure to the rectifier completes the DC circuit. Impressed current systems can have many anode configurations that are dependent upon the electrolyte and the structure to be protected.

IV. CATHODIC PROTECTION SYSTEM MONITORING & MAINTENANCE

The test points (Appendix A) that have been established for the structure should be added to the owner's periodic monitoring surveys and annual maintenance inspections to ensure that the structure continues to meet the minimum standards for cathodic protection established by NACE International using the following test procedures:

- Perform a visual examination of each system component and note any deterioration.
- Verify that each test station enclosure is undamaged and the cover properly closes/locks.
- Verify that wire and conduit at each test station is properly connected and free from breaks.
- Measure structure-to-soil potentials at each test station and other representative locations.
- Measure and record current outputs of all accessible sacrificial anodes.
- Determine the effectiveness of each accessible electrical isolation device.

V. CATHODIC PROTECTION SPARE PARTS

Spare parts are available for the cathodic protection systems from CP Solutions, Inc at www.cpsolutionsinc.net.

APPENDIX A

CATHODIC PROTECTION DATA SHEETS

TABLE 1 – MONITORING DATA FOR SACRIFICIAL ANODE CP SYSTEM

Date of Inspection	Test Station	S/S ON (-V CSE)	S/S I/O (-V CSE)	S/S Off (-V CSE)	Number Anodes	Anode I (mA)	Description of Structure

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