

Stray Current Induced Localized Corrosion of Stainless-Steel Plates in A Tainter Gate System

Hongbo Ding, Jared Pannell, Dirk van Oostendorp
Corpro
7000A Hollister Road
Houston, TX, 77040
USA

ABSTRACT

Abnormal localized corrosion of stainless steel 304 components in a Tainter gate system was observed in a low-chloride natural water environment. Through calculations, field observations and measurements, the direct cause was attributed to the combined effect of local crevice geometry and stray current interference that is induced by an adjacent foreign cathodic protection system. Based on the direct cause and the field test, mitigation strategies were proposed. It is understood that by reducing the level of stray current interference, the local potential of the stainless steel (SS) components will be decreased to the level below the pitting potential of the corresponding chloride level in the said environment. The strategies of reducing the stray current interference include lowering the positive electric field at the stray current pickup region and lowering the negative electric field at the stray current discharge region.

Key words: Stray Current Interference, Localized Corrosion, Stainless Steel, Tainter Gate, Cathodic Protection

INTRODUCTION

Localized corrosion was observed on austenitic 304 stainless steel (SS304) Embedment Plates (EP) of a Tainter gate system in a lake water environment that contains approximately 100 parts per million chloride ions. The Tainter gate is a type of radial arm floodgate used in dams to control water flow. The Tainter gate is located at the dam of a fresh-water lake in central Texas.

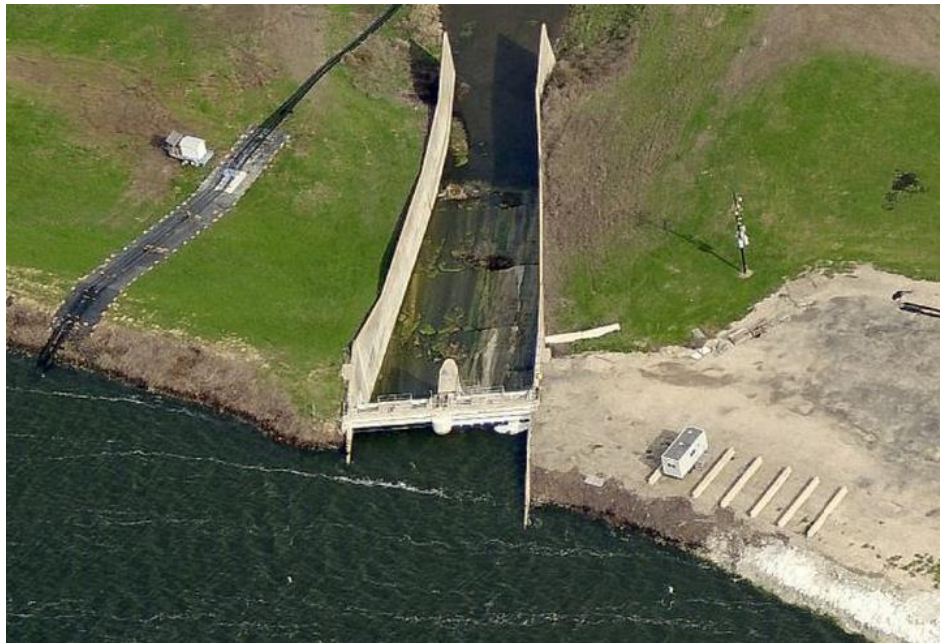


Figure 1: Aerial View of the Tainter Gate

There are two gates adjacent to each other, i.e., the South Gate (right in the image) and the North Gate (left in the image), or Gate 1 and Gate 2 respectively. The Tainter gates were installed in 2012. Magnesium anodes were originally installed, known as a galvanic anode cathodic protection (GACP), system for the subject gates. The GACP was replaced with an impressed current cathodic protection (ICCP) system in 2014. Localized corrosion was observed in 2018 on the bottom plate that is not part of the ICCP system. The location of the ICCP anodes are shown in the drawing as dashed line below (Figure 2). The corrosion is observed on the bottom plates that are not protected by the ICCP system.

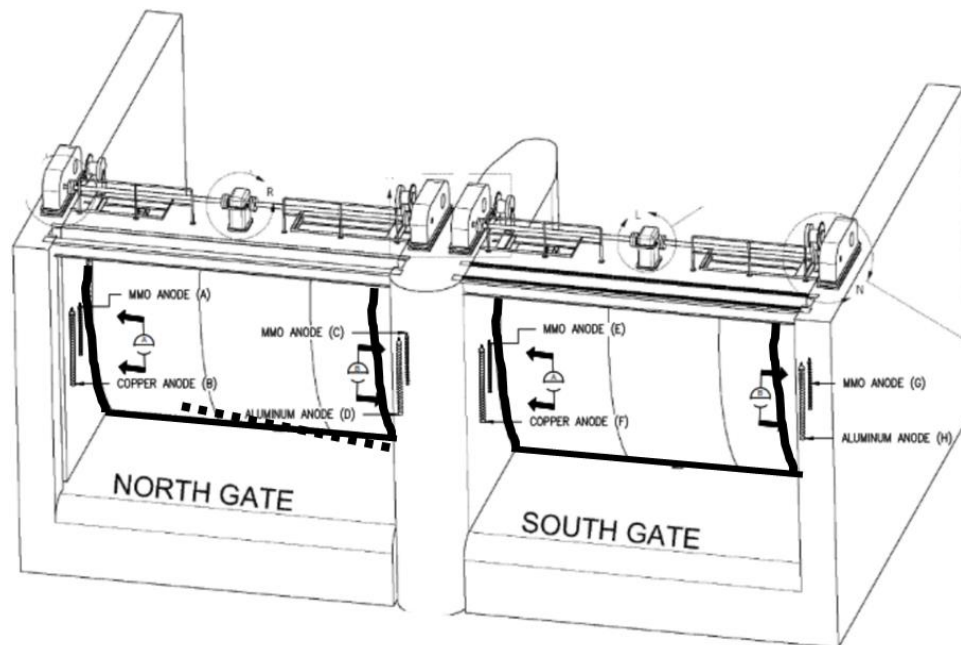


Figure 2: Diagram for the ICCP Anode Locations for the Gates and the Location of Major Corrosion

The solid line in the diagram illustrate the location of the EP plates. For clarity, the dashed line is illustrated as separate line to identify the corrosion location on the stainless steel plate.

The water analysis indicates chloride levels below 100 parts per million (ppm). In such a low chloride natural environment, localized corrosion of SS304 is not expected.¹ The present paper investigates the root causes. Based on the understanding of the abnormal corrosion mechanism, the mitigation strategies are also proposed.

INVESTIGATION PROCEDURE

The root cause analyses include the historic document review and the field investigations. The historic document review examines the past corrosion mitigation records, such as the GACP system installation and commissioning, and the installation, commissioning and annual CP survey for the ICCP system. The field investigation includes the current and potential adjustments and measurements, the current demand testing using either the water-side temporary anodes or the land-site temporary anodes. In addition, the earth potential gradients around the anodes were assessed regarding interference.

RESULTS

The results are discussed in three subsections following the sequence of the investigations.

Field Observations and Speculations

The corrosion is observed on the stainless steel embedment plate. The EP is embedded in concrete walls and floor. Corrosion of the SS304 EP was focused on areas where a crevice is formed by the contact of the EP with the rubber seal on the opposite side of the Tainter gate. The main body of the Tainter gate is made of low alloy steel that is separated from the EP. The low alloy steel gates are protected against corrosion using organic coatings and a localized ICCP system.



Figure 3: Corrosion Morphology and Location for the Stainless Steel Embedment Plate

There are also stainless steel plates on the edges of the gate to hold the rubber seal. The gate plates (GP) are intended to be electrically isolated by isolation bolts and the rubber seal. However, some of the isolation bolts were found to be defective, causing some of the GP being electrically shorted to the gate. It was found that location of the localized corrosion on the EP is exactly opposite to the location of the GP that are shorted to the low alloy steel gate.