Cathodic Protection of Underground Petroleum Storage Tanks and Piping Systems

API RECOMMENDED PRACTICE 1632
THIRD EDITION, MAY 1996

REAFFIRMED, DECEMBER 2010

energy API®

AMERICAN PETROLEUM INSTITUTE

Cathodic Protection of Underground Petroleum Storage Tanks and Piping Systems

Manufacturing, Distribution and Marketing Department

API RECOMMENDED PRACTICE 1632
THIRD EDITION, MAY 1996

REAFFIRMED, DECEMBER 2010

AMERICAN PETROLEUM INSTITUTE

SPECIAL NOTES

API publications necessarily address problems of a general nature. With respect to particular circumstances, local, state, and federal laws and regulations should be reviewed.

API is not undertaking to meet the duties of employers, manufacturers, or suppliers to warn and properly train and equip their employees, and others exposed, concerning health and safety risks and precautions, nor undertaking their obligations under local, state, or federal laws.

Information concerning safety and health risks and proper precautions with respect to particular materials and conditions should be obtained from the employer, the manufacturer or supplier of that material, or the material safety data sheet.

Nothing contained in any API publication is to be construed as granting any right, by implication or otherwise, for the manufacture, sale, or use of any method, apparatus, or product covered by letters patent. Neither should anything contained in the publication be construed as insuring anyone against liability for infringement of letters patent.

Generally, API standards are reviewed and revised, reaffirmed, or withdrawn at least every five years. Sometimes a one-time extension of up to two years will be added to this review cycle. This publication will no longer be in effect five years after its publication date as an operative API standard or, where an extension has been granted, upon republication. Status of the publication can be ascertained from the API Authoring Department [telephone (202) 682-8000]. A catalog of API publications and materials is published annually and updated quarterly by API, 1220 L Street, N.W., Washington, D.C. 20005.

This document was produced under API standardization procedures that ensure appropriate notification and participation in the developmental process and is designated as an API standard. Questions concerning the interpretation of the content of this standard or comments and questions concerning the procedures under which this standard was developed should be directed in writing to the director of the Authoring Department (shown on the title page of this document), American Petroleum Institute, 1220 L Street, N.W., Washington, D.C. 20005. Requests for permission to reproduce or translate all or any part of the material published herein should also be addressed to the director.

API publications may be used by anyone desiring to do so. Every effort has been made by the Institute to assure the accuracy and reliability of the data contained in them; however, the Institute makes no representation, warranty or guarantee in connection with this publication and hereby expressly disclaims any liability or responsibility for loss or damage resulting from its use or for the violation of any federal, state, or municipal regulation with which this publication may conflict.

API standards are published to facilitate the broad availability of proven, sound engineering and operating practices. These standards are not intended to obviate the need for applying sound engineering judgment regarding when and where these standards should be utilized. The formulation and publication of API standards is not intended in any way to inhibit anyone from using any other practices.

Any manufacturer marking equipment or materials in conformance with the marking requirements of an API standard is solely responsible for complying with all the applicable requirements of that standard. API does not represent, warrant, or guarantee that such products do in fact conform to the applicable API standard.

FOREWORD

This recommended practice describes the corrosion problems characteristic in underground steel storage tanks and piping systems and provides a general description of the two methods currently used to provide cathodic protection against corrosion.

Persons planning to construct an underground storage facility, replace existing underground storage tanks and piping systems, or cathodically protect existing underground storage tanks and piping should refer to applicable local, state, and federal fire, safety, and environmental regulations as well as the following publications:

a. API RP 1615.
b. API RP 1621.
c. NACE RP-01-69.
d. NACE RP-02-85.
e. NFPA 30.
f. NFPA 70.
g. PEI RP100-87.

At the time this recommended practice was written, legislation and regulations related to the design, installation, operation, and maintenance of cathodic protection systems for underground petroleum storage systems were under development at the federal, state, and municipal levels. Therefore, the appropriate government agencies should be consulted for regulations that apply to the area of installation prior to taking any action suggested in this recommended practice.

API publications may be used by anyone desiring to do so. Every effort has been made by the Institute to assure the accuracy and reliability of the data contained in them; however, the Institute makes no representation, warranty, or guarantee in connection with this publication and hereby expressly disclaims any liability or responsibility for loss or damage resulting from its use or for the violation of any federal, state, or municipal regulation with which this publication may conflict.

Suggested revisions are invited and should be submitted to the director of the Marketing Department, American Petroleum Institute, 1220 L Street, N.W., Washington, D.C. 20005.

CONTENTS

Page

SECTION 1—GENERAL

SECTION 2—CORROSION OF BURIED STEEL STRUCTURES

SECTION 3—SACRIFICIAL ANODE PROTECTION

SECTION 4—IMPRESSED-CURRENT PROTECTION

Figures

Table

Cathodic Protection of Underground Petroleum Storage Tanks and Piping Systems

SECTION 1—GENERAL

1.1 Scope

This recommended practice covers two methods of providing cathodic protection for buried steel petroleum storage and dispensing systems. Its intent is to provide information specific to buried steel structures such as motor fuel storage tanks and delivery piping, waste oil tanks, heating-oil tanks, and automobile lifts installed at service stations. Information presented for service stations is not necessarily applicable to buried tanks and piping used for other purposes. This recommended practice is intended to serve only as a general guide to marketers, architects, and engineers interested in cathodic protection of underground petroleum storage and dispensing systems. Specific cathodic protection designs are not provided. Such designs should be developed or adapted by a qualified corrosion engineer or a person thoroughly familiar with cathodic protection practices.

1.2 Referenced Publications

The editions of the following documents that are in effect at the time of publication of this recommended practice are cited herein:

API		
	RP 1615	*Installation of Underground Petroleum Storage Systems*
	RP 1621	*Bulk Liquid Stock Control at Retail Outlets*
NACE[1]		
	RP-01-69	*Control of External Corrosion on Underground or Submerged Metallic Piping Systems*
	RP-02-85	*Control of External Corrosion on Metallic Buried, Partially Buried, or Submerged Liquid Storage Systems*
NFPA[2]		
	30	*Flammable and Combustible Liquids Code*
	70	*National Electrical Code*
PEI[3]		
	RP100-87	*Recommended Practices for the Installation of Underground Liquid Storage Systems*

SECTION 2—CORROSION OF BURIED STEEL STRUCTURES

2.1 Introduction

Corrosion may be defined as the deterioration of metal due to a reaction with its environment. External corrosion of buried steel structures is an electrochemical process. For the process to occur, areas with different electrical potentials must exist on the metal surface. These areas must be electrically connected and in contact with an electrolyte. There are, therefore, four components in each electrochemical corrosion cell: an anode, a cathode, a metallic path connecting the anode and cathode, and an electrolyte (see Figure 1). The role of each component in the corrosion process is as follows:

a. At the anode, the base metal goes into solution (corrodes) by releasing electrons and forming positive metal ions.
b. No metal loss occurs at the cathode. However, other chemical reactions occur that consume the electrons released at the anode.
c. Positive current flows through the metal path connecting the cathode and anode. Electrons generated by the chemical corrosion reactions at the anode are conducted through the metal to the cathode where they are consumed.
d. Positive current flows through the electrolyte from the anode to the cathode to complete the electrical circuit. In the case of buried structures, the electrolyte is moist soil.

2.2 Corrosion Processes

2.2.1 GALVANIC CORROSION

2.2.1.1 Corrosion is usually not limited to a single point, as shown in Figure 1. In the case of general corrosion, thousands of microscopic corrosion cells occur randomly over the metal surface, resulting in relatively uniform metal loss. In the case of pitting, the individual corrosion cells tend to be larger, and distinct anode and cathode areas can often be identified. Metal loss may be concentrated within relatively small areas, and substantial areas of the surface may be unaffected by corrosion.

---

[1] National Association of Corrosion Engineers International, P.O. Box 218340, Houston, TX 77218.

[2] National Fire Protection Association, Batterymarch Park, Quincy, MA 02269-9990.

[3] Petroleum Equipment Institute, P.O. Box 2380, Tulsa, OK 74101.

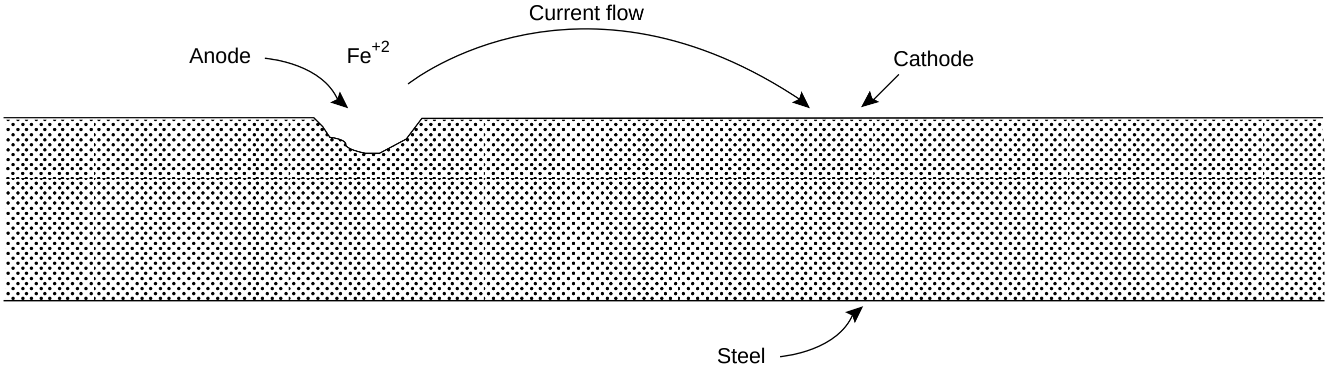

Figure 1—Electrochemical Corrosion Cell

2.2.1.2 Both metal composition and environmental factors may determine which areas on a metal surface become anodes or cathodes. Steel is an inherently nonhomogeneous material, and for a particular environment, potential differences between adjacent areas can result from uneven distribution of alloying elements or contaminants within the metal structure. Differences between the weld material and the steel plate can also cause corrosion cells in welded structures.

2.2.1.3 Physical and chemical properties of the soil (electrolyte) may also influence the location of anodic and cathodic areas on the metal surface. For example, differing oxygen concentrations at different areas on a buried steel structure may generate potential differences. Areas with lower oxygen concentrations become anodic areas, and areas with higher oxygen concentrations become cathodic areas. This may result in more severe corrosion attack at the bottom of a buried tank than at the top of the tank since oxygen concentration in soil is primarily dependent on diffusion from the soil surface (see Figure 2). The same mechanism can also contribute to corrosion in areas where clay or debris contact a steel tank buried in a sand backfill, or where a tank is buried in two different types of soil (see Figure 3).

2.2.1.4 Soil characteristics substantially affect the type and rate of corrosion occurring on buried structures. For example, dissolved salts influence the current-carrying capacity of the soil electrolyte and help determine reaction rates at anode and cathode areas. Soil moisture content, pH (a measure of acidity), and the presence of sulfides also influence corrosion. These factors, and perhaps others, interact in a complex fashion to influence corrosion at each location.

2.2.2 STRAY CURRENT AND BIMETALLIC CORROSION

2.2.2.1 In addition to galvanic corrosion, stray current corrosion and bimetallic corrosion may also be encountered on buried steel structures. Like galvanic corrosion, these corrosion processes also involve electrochemical reactions.

2.2.2.2 Stray currents are electric currents that travel through the soil electrolyte. The most common and potentially the most damaging stray currents are direct currents. These currents are generated from grounded DC electric power operations including electric railroads, subways, welding machines, and impressed-current cathodic protection systems (described in Section 4). Stray currents may enter a buried metal structure and travel through the low-resistance path of the metal to an area on the structure closer to the current source. Current leaves the structure at that point to return to the source through the soil electrolyte. Corrosion occurs at the area where current leaves the structure (see Figure 4).

2.2.2.3 Bimetallic corrosion occurs when two metals with different compositions are connected in a soil electrolyte. For example, bimetallic corrosion can occur where a bronze check valve is joined to steel piping or where galvanized pipe is connected to a steel tank. In the bronze check valve and steel pipe example, the steel pipe becomes the anode, and the bronze check valve is the cathode. Since current takes the path of least resistance, the most severe corrosion attack on the steel pipe often occurs in the area immediately adjacent to the check valve (see Figure 5).

2.3 Corrosion Control

2.3.1 INTRODUCTION

Corrosion of buried steel structures may be eliminated by proper application of cathodic protection. Cathodic protection is a technique for preventing corrosion by making the entire surface of the metal to be protected act as the cathode of an electrochemical cell. Corrosion is not eliminated. It is simply transferred from the metal surface to an external