NACE SP0100-2014
(formerly RP0100)
Item No. 21090

# Standard Practice

# Cathodic Protection to Control External Corrosion of Concrete Pressure Pipelines and Mortar-Coated Steel Pipelines for Water or Waste Water Service



Revised 2014-06-26
Revised 2008-11-07
Reaffirmed 2004-09-15
Approved 2000-01-14
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ISBN 1-57590-096-3

## Foreword

The purpose of this standard practice is to furnish guidelines that provide corrosion control personnel, owners, operators, designers, manufacturers, and contractors with information on controlling external corrosion of embedded steel in concrete pressure pipelines and mortar-coated steel pipelines for water or waste water service through the application of cathodic protection (CP). The guidelines presented are applicable to new or existing buried pipelines with or without a supplemental coating.

The provisions of this standard should be applied under the direction of competent persons who are qualified to engage in the practice of corrosion control on buried or submerged metallic pipelines. Such persons may be licensed professional engineers or persons recognized as corrosion specialists or CP specialists by NACE. The professional experience of such persons should include suitable experience in CP of prestressed concrete structures, if protection of that type of structure is being planned.

This standard was originally prepared in 2000 by NACE Task Group T-10A-28, a component of Unit Committee T-10A on Cathodic Protection. To provide the necessary expertise on all aspects of the subject and in order to receive input from all interested parties, Task Group T-10A-28 was composed of corrosion consultants, consulting engineers, architect-engineers, CP engineers, researchers, pipeline owners, and representatives from both industry and government. The standard was reaffirmed in 2004 by Specific Technology Group (STG) 05, "Cathodic/Anodic Protection" and revised in 2008 and 2014 by Task Group (TG) 019, "Mortar-Coated Pipes: Cathodic Protection Criteria." 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.* The terms *shall* and *must* are used to state a requirement, and are considered mandatory. The term *should* is used to state something good and is recommended but is not considered mandatory. The term *may* is used to state something considered optional.

# Cathodic Protection to Control External Corrosion of Concrete Pressure Pipelines and Mortar-Coated Steel Pipelines for Water or Waste Water Service

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## Section 1: General

1.1 Introduction

1.1.1 Concrete and steel are considered compatible materials because they have similar coefficients of thermal expansion and because concrete usually provides steel with excellent corrosion protection. Because of the high alkalinity of portland cement, a stable, corrosion-mitigating, passive oxide film forms on the surface of the encased steel. If this film does not form or is weakened or destroyed, corrosion can occur.

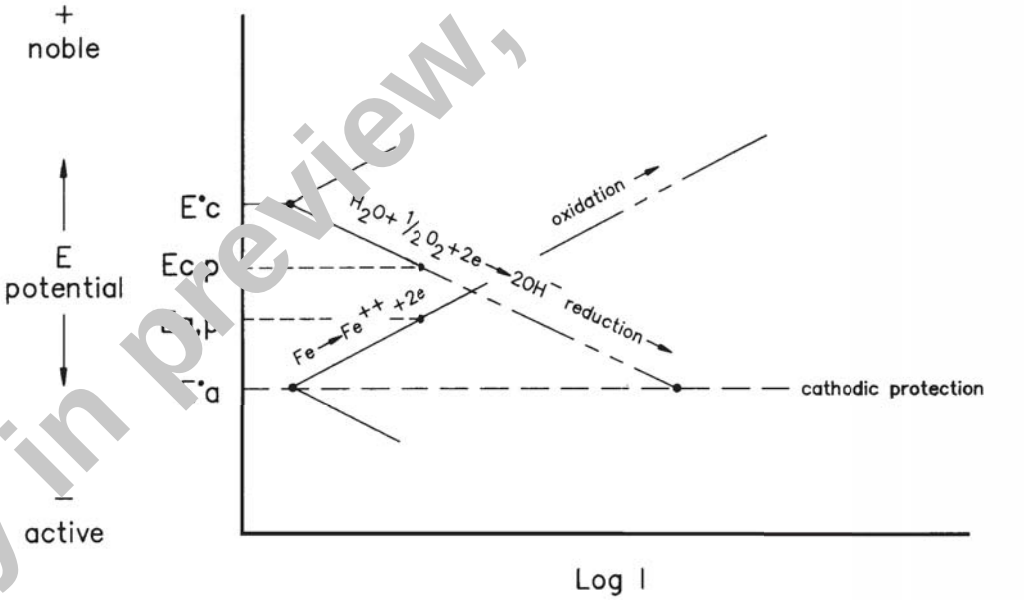
1.1.2 The protective oxide film formed on steel encased in concrete does not form or will be destroyed if the concrete does not fully encase the steel, the alkalinity of the concrete is lost by reaction with aggressive gases or liquids, or excessive amounts of chloride or other aggressive ions are present. If one or more of these conditions exists and moisture and oxygen are in contact with the steel, corrosion can occur.

1.1.3 Corrosion occurs because of the formation of an electrochemical cell. An electrochemical cell consists of four components: an anode, at which oxidation occurs; a cathode, at which reduction occurs; a metallic path through which electrical current passes as a flow of electrons; and an electrolyte (concrete pore solution) through which electrical current passes as a flow of ions in an aqueous medium. If any one of the four elements of the electrochemical cell is eliminated, corrosion is prevented.

1.1.4 Within the electrochemical cell, the location of relative anodic and cathodic areas can be determined through potential (voltage) measurements. This is accomplished by measuring the potential between a metal immersed or embedded in an electrolyte and a stable reference electrode. This technique may also be used to assess the effectiveness of CP.

1.2 Cathodic Protection (CP)

1.2.1 The basic principles of corrosion can be used to understand the effects of CP. CP is defined as a technique to reduce the corrosion of a metal surface by making that surface the cathode of an electrochemical cell (see Figure 1).




E•a: Equilibrium or "open circuit" potential of anodic area
E•c: Equilibrium or "open circuit" potential of cathodic area
Ea,p: Polarized potential of anodic area (potential as observed on real structure)
Ec,p: Polarized potential of cathodic area (potential as observed on real structure)

**Figure 1: Polarization diagram.[1]**

1.2.2 If corrosion of steel is found in a concrete pressure pipeline or a mortar-coated steel pipeline, CP may be used to control further corrosion. However, CP does not replace lost steel or return corroded steel to its original cross-section.

1.2.3 Electrical continuity of the steel elements within the pipe sections and between individual pipe sections is required for adequate CP; see Paragraph 6.8.

1.3 This standard serves as a guideline for establishing minimum requirements for CP of the following:

1.3.1 New pipelines: CP is usually not required on new pipelines because of the passive film that forms on steel embedded in portland cement concrete or portland cement mortar. Cracks or damage caused by construction activities may be a consideration for application of CP. Environmental conditions described in Paragraph 1.1.2 also warrant consideration of CP; otherwise, the pipeline should be monitored periodically to determine whether corrosion might be occurring.

1.3.2 Existing pipelines: Studies should be made to determine the extent of active corrosion on the pipeline. If these studies indicate that corrosion is affecting the safe or economic operation of the pipeline, adequate corrosion control measures, which may include CP, should be taken.

1.3.3 CP should be provided and maintained if investigations indicate that corrosion is or might be occurring and adequate electrical continuity exists or can be established.

1.4 Special conditions sometimes exist in which CP is ineffective or only partially effective, such as shielding by nearby structures. Deviation from this standard may be warranted in specific situations provided that the corrosion control personnel in charge demonstrate that the objectives expressed in this standard are achieved.

1.5 For accurate and correct application, this standard must be used in its entirety. Using or citing only specific paragraphs or sections can lead to misinterpretation and misapplication of the recommendations and practices contained in this standard. This standard does not designate practices for every specific situation because of the complexity of conditions to which buried or submerged pipelines are exposed.

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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. It is usually the electrode where corrosion occurs and metal ions enter solution.)

**Attenuation:** Electrical losses in a conductor caused by current flow in the conductor.

**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 rate of a metal surface by making that surface the cathode of an electrochemical cell.

**Continuity Bond:** A connection, usually metallic, that provides electrical continuity between structures that can conduct electricity.

**Electrical Continuity:** The condition of being electrically connected to other metallic components or structures.

**Electrical Isolation:** The condition of being electrically separated from other metallic structures or the environment.

**Electrolyte:** A chemical substance containing ions that migrate in an electric field.

**Energizing (Turn-On):** The process of initially applying power to a CP system.

**Foreign Structure:** Any metallic structure that is not intended as a part of a system under cathodic protection.

**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.

**Groundbed:** One or more anodes installed below the earth's surface for the purpose of supplying cathodic protection current.