

# **Standard Practice**

# Control of External Corrosion on Underground or Submerged Metallic Piping Systems

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### Foreword

This standard presents methods and practices for achieving effective control of external corrosion on underground or submerged metallic piping systems. These methods and practices are also applicable to many other underground or submerged metallic structures. It is intended for use by corrosion control personnel concerned with the corrosion of underground or submerged piping systems, such as those used for the transport of oil, gas, water, and other fluids. This standard describes the use of electrically insulating coatings, electrical isolation, and cathodic protection (CP) as they relate to external corrosion control. This standard does not include corrosion control methods based on injection of chemicals into the environment, on the use of electrically conductive coatings, or on the use of nonadhered polyethylene encasement (refer to NACE Publication 10A292).<sup>1</sup> The standard contains specific provisions for the application of CP to existing uncoated, existing coated, and new piping systems. Also included are methods for control of stray currents on pipelines.

This standard should be used in conjunction with the practices described in the following NACE standards and publications, when appropriate (use latest revisions):

SP0572<sup>2</sup>

SP0177<sup>3</sup>

SP0285<sup>4</sup>

SP0286<sup>5</sup>

SP0188<sup>6</sup>

TPC 11<sup>7</sup>

TM0497<sup>8</sup>

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 practices contained in this standard.

This standard does not designate practices for every specific situation because of the complexity of conditions to which underground or submerged piping systems are exposed. This standard is not intended to apply to offshore pipelines and structures. For these facilities, the recommended NACE standards are NACE SP0607/ISO 15589-2<sup>9</sup> for offshore pipelines, and SP0176<sup>10</sup> for offshore structures. Definitions of onshore and offshore vary, and it is the responsibility of the user to determine which of the above standards apply to pipelines across coastal boundaries.

This standard was originally published in 1969, and was revised by NACE Task Group T-10-1 in 1972, 1976, 1983, and 1992. It was reaffirmed in 1996 by NACE Unit Committee T-10A, "Cathodic Protection," and in 2002 and 2007 by Specific Technology Group (STG) 35, "Pipelines, Tanks, and Well Casings." It was revised in 2013 by Task Group (TG) 360, "Piping Systems: Review of SP0169-2007 (formerly RP0169), 'Control of External Corrosion on Underground or Submerged Metallic Piping." This standard is issued by NACE International under the auspices of STG 35, which is composed of corrosion control personnel from oil and gas transmission companies, gas distribution companies, power companies, corrosion consultants, and others concerned with external corrosion control of underground or submerged metallic piping systems.

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.

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# **Standard Practice**

# Control of External Corrosion on Underground or Submerged Metallic Piping Systems

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### Section 1: General

1.1 This standard presents accepted methods and practices for the control of external corrosion on buried or submerged steel, stainless steel, cast iron, ductile iron, copper, and aluminum piping systems.

1.2 This standard is intended to serve as a guide for establishing requirements for control of external corrosion on the following systems:

1.2.1 New piping systems: A proven method of corrosion control (e.g., coating supplemented with CP) should be provided in the initial design and maintained during the service life of the piping system, unless investigations indicate that corrosion control is not required. Consideration should be given to the construction of piping in a manner that facilitates the use of inline inspection (ILI) tools.

1.2.2 Existing coated piping systems: CP should be provided and maintained (which includes the maintenance of coating as necessary), unless investigations indicate that CP is not required.

1.2.3 Existing uncoated piping systems: Studies can be made to determine the extent and rate of corrosion on existing uncoated piping systems. When these studies indicate that corrosion affects the safe or economic operation of the system, adequate corrosion control measures shall be taken.

1.3 The provisions of this standard are intended to be applied under the direction of competent persons who, by reason of knowledge of the physical sciences and the principles of engineering and mathematics, acquired by education and related practical experience, are qualified to engage in the practice of corrosion control on underground or submerged metallic piping systems.

Note: Such persons might be, but are not limited to, registered professional engineers or persons recognized as Corrosion Specialists or CP Specialists by NACE, if their professional activities include suitable experience in external corrosion control of underground or submerged metallic piping systems.

1.4 Special conditions in which CP is ineffective or only partially effective sometimes exist (see Paragraph 6.2.1.4 for examples). Deviation from this standard might be warranted in specific situations provided that corrosion control personnel in responsible charge are able to demonstrate that the objectives expressed in this standard have been achieved.

1.5 This standard is not intended for use in the control of internal corrosion.

# Section 2: Definitions,<sup>(1)</sup> Abbreviations, and Acronyms

**Definitions:** 

Amphoteric Metal: A metal that is susceptible to corrosion in both acid and alkaline environments.

**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.)

**Anode Bed:** One or more anodes installed—underground or submerged—for the purpose of supplying cathodic protection. It is often called a groundbed.

**Backfill:** Material placed in a hole to fill the space around the anodes, vent pipe, and buried components of a cathodic protection system. For the purposes of this standard, "backfill" is also defined as the material (native or imported) used to fill a pipeline trench.

Beta Curve: A plot of dynamic (fluctuating) stray current or related proportional voltage (ordinate) versus the corresponding structure-to-electrolyte potentials at a selected location on the affected structure (abscissa). For the purposes of this standard,

<sup>&</sup>lt;sup>(1)</sup> Definitions in this section reflect common usage among practicing corrosion control personnel and apply specifically to how the terms are used in this standard. In many cases, in the interests of brevity and practical usefulness, the scientific definitions are abbreviated or paraphrased.

#### SP0169-2013

"Beta Curve" is defined as a correlation between the pipe-to-soil potential of the affected pipeline and the open-circuit potential between the affected pipeline and the stray current source.

Cable: One conductor or multiple conductors insulated from one another.

Casing: A metallic pipe (normally steel) installed to contain a pipe or piping.

**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 Polarization:** (1) The change of electrode potential caused by a cathodic current across the electrode/electrolyte interface; (2) a forced active (negative) shift in electrode potential. See *Polarization*.

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

Cathodic Protection Criterion: Standard for assessment of the effectiveness of a cathodic protection system.

**Coating:** (1) A liquid, liquefiable, or mastic composition that, after application to a surface, is converted into a solid protective, decorative, or functional adherent film; (2) (in a more general sense) a thin layer of solid material on a surface that provides improved protective, decorative, or functional properties. Coatings used in conjunction with cathodic protection are electrically isolating materials applied to the surface of the metallic structure that provides an adherent film that isolates the metallic structure from the surrounding electrolyte. The thickness and structure of the coating type vary according to the environment and application parameters.

Coating Disbondment: The loss of adhesion between a coating and the pipe surface.

**Coating System:** The complete number of coats and type applied to a substrate in a predetermined order. (When used in a broader sense, surface preparation, pretreatments, dry film thickness, and manner of application are included.)

Conductor: A material suitable for carrying an electric current. It can be bare or insulated.

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

**Correlation:** (1) A causal, complementary, parallel, or reciprocal relationship, as by having corresponding characteristics. (2) (As used in Section 9) Simultaneous measurement of two dynamic (time-varying) parameters, e.g., voltage and current, presented in an X-Y plot to determine the relative relationship between the two parameters and whether the fluctuations over time are caused by one or more sources of stray current.

**Corrosion:** The deterioration of a material, usually a metal, that results from a chemical or electrochemical reaction with its environment.

**Corrosion Potential (E**<sub>corr</sub>): The potential of a corroding surface in an electrolyte measured under open-circuit conditions relative to a reference electrode (also known as *electrochemical corrosion potential, free corrosion potential, open-circuit potential*).

**Corrosion Rate:** The time rate of progress of corrosion. (It is typically expressed as mass loss per unit area per unit time, penetration per unit time, etc.)

**Current Applied Potential:** The half-cell potential of an electrode measured while protective current flows through the electrolyte environment, typically measured with respect to a reference electrode placed at the soil surface.

**Current Density:** The electric current to or from a unit area of an electrode surface.

Diode: A bipolar semiconducting device having a low resistance in one direction and a high resistance in the other.

**Disbondment:** The loss of adhesion between a coating and the substrate.

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**Distributed-Anode Impressed Current System:** An impressed current anode configuration in which the anodes are "distributed" along the structure at relatively close intervals such that the structure is within each anode's voltage gradient. This anode configuration causes the electrolyte around the structure to become positive with respect to remote earth.

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

Electrical Shielding: Preventing or diverting the cathodic protection current from its intended path.

**Electrical Survey**: Any technique that involves coordinated electrical measurements taken to provide a basis for deduction concerning a particular electrochemical condition relating to corrosion or corrosion control.

**Electrode:** A material that conducts electrons, is used to establish contact with an electrolyte, and through which current is transferred to or from an electrolyte.

**Electrolytically Contacted Pipeline Casing:** A casing that contains soil or water electrolyte in contact with both the casing and the carrier pipe.

**Electroosmotic Effect:** Passage of a charged particle through a membrane under the influence of a voltage. Soil or coatings can act as the membrane.

**Electrolyte:** A chemical substance containing ions that migrate in an electric field. For the purposes of this standard, "Electrolyte" refers to the soil or liquid adjacent to and in contact with an underground or submerged metallic piping system, including the moisture and other chemicals contained therein.

**Empirical:** Originating in or based on observation or experience.

Free Corrosion Potential: See Corrosion Potential.

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.

Galvanic Series: A list of metals and alloys arranged according to their corrosion potentials in a given environment.

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.)

**In-Line Inspection:** The inspection of a pipeline using an electronic instrument or tool that travels along the interior of the pipeline.

**Instant-Off Potential:** The polarized half-cell potential of an electrode taken immediately after the cathodic protection current is stopped, which closely approximates the potential without IR drop (i.e., the polarized potential) when the current was on.

Interference: Any electrical disturbance on a metallic structure as a result of stray current.

**Interference Bond:** An intentional metallic connection, between metallic systems in contact with a common electrolyte, designed to control electrical current interchange between the systems.

IR Drop: See Voltage Drop.

Isolation: See Electrical Isolation.

Line Current: The direct current flowing in a pipeline.

**Linear Anode Impressed Current System:** An impressed current anode configuration in which a continuous anode is installed parallel to the structure such that the structure is within the anode voltage gradient.

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