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Merilne tehnike za katodno zaščito

Cathodic protection measurement techniques

Messverfahren für den kathodischen Korrosionsschutz

Techniques de mesures applicables en protection cathodique

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Techniques de mesures applicables en protection cathodique

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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Foreword

This document (EN 13509:2003) has been prepared by Technical Committee CEN/TC 219 "*Cathodic protection*", the secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by November 2003, and conflicting national standards shall be withdrawn at the latest by November 2003.

This European Standard should be considered as a basic document developing general measurement techniques applicable for the protection of buried or immersed metallic structures.

Annexes A, B, C, D, E, F, G, I, J and K are informative.

Annex H is normative.

This document includes a Bibliography.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovakia, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

This European Standard describes the principles of the different methods of measurement used to assist in the design of the cathodic protection system of a buried or immersed metallic structure, for the verification of its effectiveness and finally for its optimum operational conditions.

It deals in particular with the measurement of the structure to electrolyte potential, which indicates whether or not the cathodic protection criterion for the structure is met.

Apart from specifying the factors, which may influence the measurement of the potential, this European Standard describes the different techniques possible and their suitability in various situations.

Further, this European Standard provides parameters to be controlled and measurements to be carried out (potential, potential gradient, current and resistance measurements) to ensure the correct functioning of the cathodic protection system and its effectiveness for the entire structure.

Several measurement methods described in general terms in the body of the standard are explained in more detail in annexes. These methods differ from one another to account for differences in type or state of the structure, the local environment and the degree of accuracy selected.

Measurements on buried structures that are not easily accessible e.g. pipe networks in urban areas are difficult to implement and interpret. To take measurements without the full knowledge of the problems associated with the measurement technique renders the interpretation of the measurements difficult and leads to incorrect decisions.

One of the clauses of this European Standard therefore outlines the difficulties encountered when measuring structure to electrolyte potentials, and suggests several methods of measurement that take into account, or avoid, these difficulties.

Based on knowledge and experience, the most suitable measurement techniques can be selected as described in this European Standard.

In order to achieve effective and efficient cathodic protection, measurements should be performed by trained, experienced and responsible personnel.

Instrumentation used for measurement should be kept in good working order and should be subjected to periodical calibration and safety checks.

1 Scope

This European Standard deals with the cathodic protection against corrosion of buried or immersed metallic structures, detailing the measuring methods to be used for assessing the effectiveness of cathodic protection as well as the measurements and measures taken to monitor cathodic protection during operation.

Throughout the text, the measurement techniques are described primarily for pipelines.

However, they are sufficiently general to apply to other kinds of buried or immersed (except offshore) structures.

General principles with regard to cathodic protection are described in EN 12954. Other measurement methods specific to particular cases are described in other European Standards e.g. prEN 50162.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text, and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN 12954:2001, *Cathodic protection of buried or immersed metallic structures — General principles and application for pipelines*

EN ISO 8044:1999, *Corrosion of metals and alloys — Basic terms and definitions (ISO 8044:1999)*

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this European Standard the following terms and definitions apply. For other terms and definitions related to corrosion refer to EN ISO 8044:1999 and to cathodic protection refer to EN 12954:2001.

3.1.1
anode backfill
material with a low resistivity, which may be moisture-retaining, immediately surrounding a buried anode for the purpose of decreasing the effective resistance of the anode to the electrolyte

3.1.2
backfill
see anode backfill

3.1.3
bond
metal conductor, usually of copper, connecting two points on the same or on different structures usually with the intention of making the points equipotential

3.1.4
buried structure
any metal construction built or laid beneath ground level or built on ground level and then covered with earth

3.1.5
calomel reference electrode
reference electrode consisting of mercury and mercurous chloride in a solution of potassium chloride

3.1.6
cathodic protection system
entire installation, including active and passive elements, that provides cathodic protection

3.1.7
cell current
current flowing in a corrosion cell

3.1.8
coating defect
deficiency in the protective coating (e.g. holidays, porosity)

3.1.9
coating resistance or structure to soil resistance (*R*co)
electrical resistance between a coated metal and the electrolyte expressed in ohms. It is determined largely by the size and number of coating defects, coating pores and the electrolyte resistivity

3.1.10
copper/saturated copper sulphate reference electrode
reference electrode consisting of copper in a saturated solution of copper sulphate

3.1.11
coupon
representative metal sample used to quantify the extent of corrosion or the effectiveness of applied cathodic protection

3.1.12
d.c. traction system
electrical traction system powered by direct current

NOTE If these systems have the return circuit earthed at more than one point or are not completely isolated they can generate stray currents, which may cause corrosion damage.

3.1.13
d.c. industrial plant
electrical system, other than a traction system, powered by direct current

NOTE If these systems use the earth as a part of the return circuit, they can generate stray currents, which may cause corrosion damage. Cathodic protection systems use the earth as a part of the circuit.

3.1.14
electrolyte
liquid, or the liquid component in a medium such as soil, in which electric current flows by the movement of ions

3.1.15
electrolyte resistivity (ρ)
the specific electric resistance of the electrolyte assuming that the electrolyte is homogeneous

NOTE Usually expressed in Ωm.

3.1.16
equalising currents
currents that flow between areas of different polarisation after switching off the protection current. Equalising currents can be a source of error in measuring IR free potentials

3.1.17
external potential test probe
installation comprising a coupon with an associated reference electrode to provide structure to electrolyte potential measuring facilities devoid of IR drop errors

3.1.18
foreign anode
see Foreign Electrode

3.1.19
foreign cathode
see Foreign Electrode

3.1.20
foreign electrode
foreign electrode is either a foreign anode or a foreign cathode. A foreign anode is a metal or a conductive material in contact with the structure under consideration which has a more negative potential than the structure and a foreign cathode is a metal or a conductive material in contact with the structure under consideration, which has a more positive potential than the structure

3.1.21
foreign structures
any neighbouring structure other than the structure that is under consideration

3.1.22
galvanic anode
anode that provides cathodic protection current by means of galvanic action

3.1.23
holiday
defect in a protective coating at which metal is exposed to the environment

3.1.24
immersed structure
any metal construction, or part of a construction laid in a liquid environment such as fresh water (rivers, lakes), brackish water (estuaries), or sea water

3.1.25
insulated flange
flanged joint between adjacent lengths of pipe in which the nuts and bolts are electrically insulated from one or both of the flanges and the gasket is non-conducting, so that there is an electrical discontinuity in the pipeline at that point

3.1.26
interference
any change of the structure to electrolyte potential, which is caused by foreign electrical sources

3.1.27
IR drop
voltage, due to any current, developed in an electrolyte such as the soil, between the reference electrode and the metal of the structure, in accordance with Ohm's Law (U = I .R)

3.1.28
IR free potential ($E_{IR\ free}$)
structure to electrolyte potential measured without the voltage error caused by the IR drop due to the protection current or any other current

3.1.29
isolating joint
electrically discontinuous connection between two lengths of pipe, inserted in order to provide electrical discontinuity between them, e.g. monobloc isolating joint, insulated flange

3.1.30
measuring electrode
electrode with a stable potential in a given electrolyte used to determine the potentials of a structure in that electrolyte. The potential of a measuring electrode in a given electrolyte has to be determined with respect to a reference electrode

3.1.31
measuring point
point at which the actual measurement takes place. In the case of structure to electrolyte potentials this refers to the location of the reference electrode

3.1.32
off potential (E_{off})
structure to electrolyte potential measured immediately after synchronous interruption of all sources of applied cathodic protection current

3.1.33
on potential (E_{on})
structure to electrolyte potential measured with the cathodic protection current flowing

3.1.34
permanent reference electrode
permanently buried or immersed reference electrode designed for a long life and installed close to the structure

3.1.35
polarisation
change in the potential of an electrode (e.g. structure) as the result of current flow to or from that electrode

3.1.36
potential gradient
difference in potential between two separate points in the same electric field

3.1.37
potential test probes
see External Potential Test Probe

3.1.38
protected structure
structure to which cathodic protection is effectively applied

3.1.39
protection current (I_p)
current made to flow into a metallic structure from its electrolytic environment in order to effect cathodic protection of the structure

3.1.40
protection potential
structure to electrolyte potential for which the metal corrosion rate is acceptable

3.1.41
silver/silver chloride electrode
measuring electrode consisting of silver, coated with silver chloride, in an electrolyte containing chloride ions

3.1.42
silver/silver chloride reference electrode
reference electrode consisting of silver, coated with silver chloride, in an electrolyte containing a fixed concentration of chloride ions

3.1.43
standard hydrogen electrode
reference electrode, used as a standard in laboratories, consisting of an inert metal, such as platinum, in an electrolyte containing hydrogen ions at unit activity and saturated with hydrogen gas at one standard atmosphere

3.1.44
structure
metallic construction, whether coated or not, which is in contact with an electrolyte (e.g. soil, water)

NOTE The structure can represent a construction of great length, such as a pipeline, pipe networks, and underground electric cables, or well casings as well as construction on a smaller scale such as piles, sheet pilings, tanks or other underground constructions.

3.1.45
structure to electrolyte potential (also called electrode potential)
difference in potential between a structure and a specified reference electrode in contact with the electrolyte at a point sufficiently close to, but without actually touching the structure

3.1.46
test probe
see External Potential Test Probe

3.1.47
test station
installation that provides measuring and test facilities for the buried structure. Such installations will include cabling and structure connections

3.1.48
zinc electrode
measuring electrode made from sufficiently pure zinc

3.2 Symbols

I	Current
E	Potential
R	Resistance
J	Current density
U	Voltage
a	Year
a.c.	Alternating current
d.c.	Direct current

E_{Ag}	Metal to electrolyte potential with respect to a silver/silver chloride Electrode
E_{Cu}	Metal to electrolyte potential with respect to a copper/saturated Copper sulphate reference electrode
$E_{IR\ free}$	IR free potential
E_{KCl}	Metal to electrolyte potential with respect to a silver/silver Chloride/saturated potassium chloride reference electrode
E_n	Free corrosion potential
E_{off}	Off potential
E_{on}	On potential
E_p	Protection potential
E_{Hg}	Metal to electrolyte potential with respect to a Mercury/calomel/saturated potassium chloride reference electrode
E_H	Metal to electrolyte potential with respect to a standard hydrogen reference electrode
E_{Zn}	Metal to electrolyte potential with respect to a zinc electrode
I_p	Protection current
I_s	Stray current
R_{co}	Coating resistance (Ω)
T	Temperature
t	Time
ρ	Resistivity (Ω.m)

4 Buried structure to electrolyte potential

Criteria for cathodic protection are generally based on the value of the structure to electrolyte potential. Measurement of the potential is therefore necessary in order to assess the effectiveness of the cathodic protection. This subclause describes different potential determination methods.

4.1 Electrical equipment

The type and use of the instrument for measurement should be suitable for the prevailing electrical and environmental conditions (see annex H).

Instrumentation used for measurement shall be kept in good working order and shall be subjected to periodical calibration and safety checks.

4.2 Potential measurement

Since only bare metal (e.g. at the coating holidays) is likely to suffer significant corrosion, the measurement, indicating whether or not the protection potential E_p is fulfilled, would have to be made right on the metal/electrolyte phase boundary, e.g. metal/soil boundary (see EN 12954).

As this is not technically feasible, other techniques shall be applied to assess the effectiveness of cathodic protection. The most suitable one has to be selected on the basis of the local conditions in the field, e.g. coating type and quality, soil resistivity and presence of stray currents.

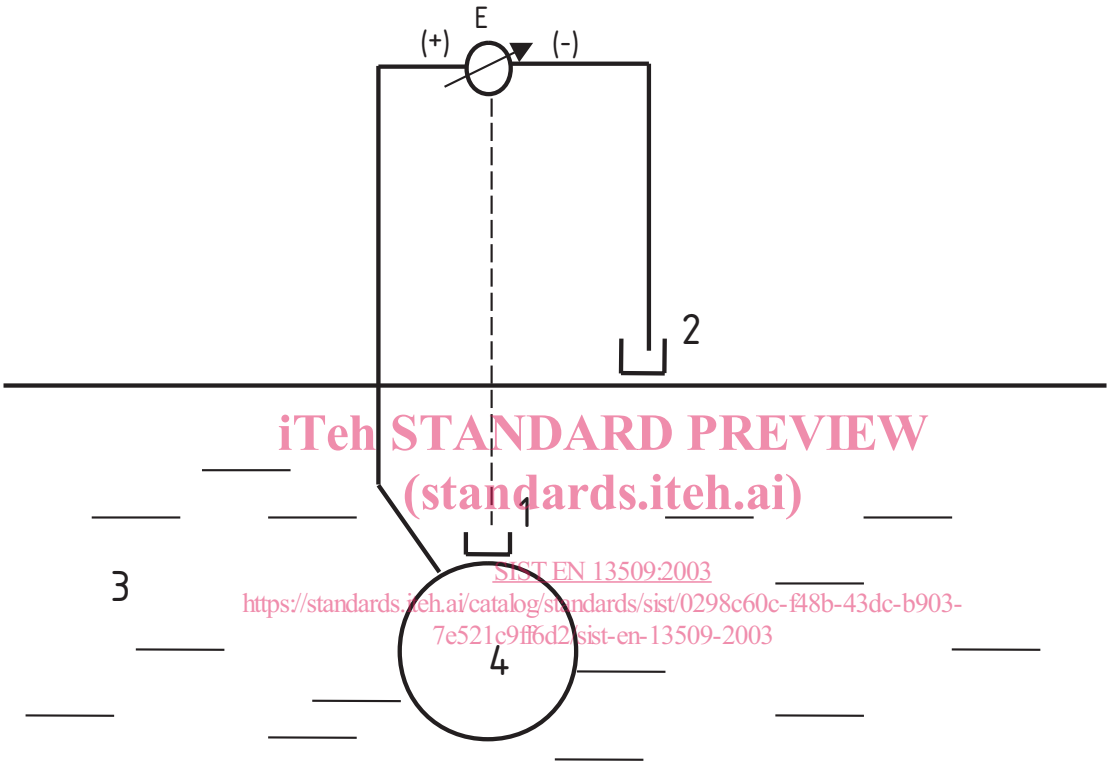
Generally, structures to electrolyte potentials are measured using a reference electrode placed on the soil surface (see Figure 1). Potential values of various normally used reference and measuring electrodes with respect to the standard hydrogen electrode are listed in annex A.

Saturated calomel electrode shall not be used in soil or water because, among other things, the risk of leakage of mercury from the electrodes.

In case of disbonded coating, potential measurement may give incorrect indications [1].

4.3 Factors influencing the potential measurement

Figure 1 shows locations of reference electrodes for structure to electrolyte potential measurements.



Key

1 and 2 Reference electrode locations
3 Soil
4 Pipe

Figure 1 — Possible locations of reference electrodes for measurement of structure to electrolyte potentials

[1] Where water flows between a loose coating and the structure surface, the potential measured is not representative of the electrochemical phenomena that occur under the disbonded coating.