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Cathodic protection measurement techniques

Techniques de mesures applicables en protection
cathodique

Messverfahren für den kathodischen Korrosionsschutz

This European Standard was approved by CEN on 27 December 2002.

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Contents

Page

Foreword	3
Introduction	4
1 Scope.....	5
2 Normative references.....	5
3 Terms, definitions and symbols	5
3.1 Terms and definitions.....	5
3.2 Symbols	9
4 Buried structure to electrolyte potential.....	10
4.1 Electrical equipment	10
4.2 Potential measurement.....	10
4.3 Factors influencing the potential measurement.....	11
4.4 Potential measurement techniques.....	13
4.4.1 Measuring technique including IR drop (on potential measurement).....	13
4.4.2 Measuring techniques to determine IR free potentials ($E_{ir\ free}$).....	13
5 Immersed structure to electrolyte potential	16
5.1 Electrical equipment	16
5.2 Potential measurements.....	16
5.2.1 Direct potential measurement methods.....	16
5.2.2 Indirect potential measurement method.....	17
6 Other measurements	17
6.1 Current measurements (d.c.)	17
6.2 Isolating joints.....	17
6.3 Foreign structures.....	18
6.4 Coating.....	18
Annex A (informative) Table A.1 - Electrodes for Potential Measurements in Soil and/or Aqueous Media.....	19
Annex B (informative) Current reduction technique	20
Annex C (informative) Above ground surveys used to measure pipe to soil potential along a buried pipeline.....	22
Annex D (informative) Above ground surveys used to assess the coating condition and to locate coating defects.....	23
Annex E (informative) Special off potential measurements in stray currents areas	25
Annex F (informative) Explanatory note on the use of the intensive measurement technique and the calculation of the IR free potential ($E_{IR\ free}$)	26
Annex G (informative) Examples of typical coupons and external potential test probe for pipe	28
Annex H (normative) Accuracy of potential measuring equipment.....	29
Annex I (informative) Accuracy of current measurement.....	31
Annex J (informative) Evaluation of the resistance of isolating joints	33
Annex K (informative) Current injection test on isolating joints	35
Bibliography	37

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.

EN 13509:2003 (E)

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

EN 13509:2003 (E)

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 ($U = I \cdot R$)

EN 13509:2003 (E)

3.1.28

IR free potential ($E_{IR \text{ free}}$)

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 piling, 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