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Cathodic protection of harbour installations

Protection cathodique des installations portuaires

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 13174 was prepared by the European Committee for Standardization (CEN) Technical Committee CEN/TC 219, *Cathodic protection*, in collaboration with Technical Committee ISO/TC 156, *Corrosion of metals and alloys*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

ISO 13174 cancels and replaces EN 13174:2001, which has been technically revised.

Introduction

Cathodic protection is applied, sometimes in conjunction with protective coatings, to protect the external surfaces of steel harbour installations and appurtenances from corrosion due to seawater, brackish water, saline mud or soil fill.

Cathodic protection works by supplying sufficient direct current to the immersed external surface of the structure to change the steel to electrolyte potential to values where corrosion is insignificant.

The general principles of cathodic protection in seawater are detailed in ISO 12473. The general principles of cathodic protection in soils are detailed in EN 12954.

Cathodic protection of harbour installations

1 Scope

1.1 General

This International Standard defines the means to be used to ensure that cathodic protection is efficiently applied to the immersed and driven/buried metallic external surfaces of steel port, harbour, coastal and flood defence installations and appurtenances in seawater and saline mud to provide protection from corrosion.

1.2 Structures

This International Standard specifies cathodic protection of fixed and floating port and harbour structures. This includes piers, jetties, dolphins (mooring and berthing), sheet or tubular piling, pontoons, buoys, floating docks, lock and sluice gates. It also specifies cathodic protection of the submerged areas of appurtenances, such as chains attached to the structure, when these are not electrically isolated from the structure.

This International Standard is to be used in respect of cathodic protection systems where the anodes are exposed to water or saline mud. For buried areas, typically in soil or sand filled areas behind piled walls or within filled caissons, which may be significantly affected by corrosion, specific cathodic protection design and operation requirements are defined in EN 12954, the anodes being exposed to soils.

This International Standard does not cover the cathodic protection of fixed or floating offshore structures (including offshore loading buoys), submarine pipelines or ships.

This International Standard does not include the internal protection of surfaces of any components such as ballast tanks, internals of floating structures flooded compartments of lock and sluice gates or the internals of tubular steel piles.

1.3 Materials

This International Standard covers the cathodic protection of structures fabricated principally from bare or coated carbon and carbon manganese steels.

As some parts of the structure may be made of metallic materials other than carbon steels, the cathodic protection system should be designed to ensure that there is a complete control over any galvanic coupling and minimize risks due to hydrogen embrittlement or hydrogen-induced cracking (see ISO 12473).

This International Standard does not address steel reinforced concrete structures (see ISO 12696).

1.4 Environment

This International Standard is applicable to the whole submerged zone in seawater, brackish waters and saline mud and related buried areas which can normally be found in port, harbour, coastal and flood defence installations wherever these structures are fixed or floating.

For surfaces which are alternately immersed and exposed to the atmosphere, the cathodic protection is only effective when the immersion time is long enough for the steel to become polarized. Typically, effective cathodic protection is achieved for all surfaces below mid tide.

For structures such as sheet steel and tubular steel piles that are driven into the sea bed or those that are partially buried or covered in mud, this International Standard is also applicable to the surfaces buried, driven and exposed to mud which are intended to receive cathodic protection along with surfaces immersed in water.

Cathodic protection may also be applied to the rear faces of sheet steel piled walls and the internal surfaces of filled caissons. Cathodic protection of such surfaces is specified by EN 12954.

This International Standard is applicable to those structures which are, or may be in the future, affected by "Accelerated Low Water Corrosion" (ALWC) and other more general forms of microbial corrosion (MIC) or other forms of so-called "concentrated corrosion" associated with galvanic couples, differential aeration and other local corrosion influencing parameters

NOTE Information is available in BS 6349-1:2000, Clause 59 and CIRIA C634 (see Bibliography)

1.5 Safety and environment protection

This International Standard does not address safety and environmental protection aspects associated with cathodic protection to which national or international regulations apply.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 12473, *General principles of cathodic protection in sea water*

EN 12496, *Galvanic anodes for cathodic protection in seawater and saline mud*

ISO 12696, *Cathodic protection of steel in concrete*

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

EN 13509, *Cathodic protection measurement techniques*

EN 50162, *Protection against corrosion by stray current from direct current systems*

3 Terms and definitions

For the purposes of this document, the terms and definitions in ISO 12473 and the following apply.

3.1
accelerated low water corrosion
ALWC
localised corrosion generally found on the sea side at or just below the LAT level of structures, but can be present at all immersed levels

Note 1 to entry: This phenomenon is associated with microbiologically influenced corrosion (MIC) and generally quiescent conditions. (See CIRIA C634.) Corrosion rates, without cathodic protection, can be as high as 2 mm/side/year and the corrosion is typically localized as large, open pitting

3.2
atmospheric zone
zone located above the splash zone, i.e. above the level reached by the normal swell, whether the structure is moving or not

3.3
buried zone
zone located under the mud line or in soil or fill

3.4
cathodic protection zone
that part of the structure which can be considered independently with respect to cathodic protection design

3.5
coating breakdown factor
F
ratio of cathodic current density for a coated metallic material to the cathodic current density of the bare material

3.6
driving voltage
difference between the structure/electrolyte potential and the anode/electrolyte potential when the cathodic protection is operating

3.7
HAT
level of highest astronomical tide

3.8
immersed zone
zone located above the mud line and below the extended tidal zone or the water line at a draught corresponding to the normal working conditions

3.9
LAT
level of lowest astronomical tide

3.10
MTL
mean tide level (also known as MSL mean sea level or MWL mean water level)

3.11
microbial corrosion
corrosion associated with the action of micro-organisms present in the corrosion system

Note 1 to entry: Also called microbiologically influenced corrosion (MIC).

3.12
ROV
remotely operated vehicle

3.13
piling
foundation, tubular or sheet steel element forming part or whole of a harbour structure

3.14
splash zone
the elevation of the structure which is intermittently wet and dry due to the wave action just above the HAT

3.15
submerged zone
zone including the buried zone, the immersed zone, the transition zone and the lower part of the tidal zone under the MWL
See Figure 1.

3.16
transition zone
zone located below LAT and including the possible level inaccuracy of the structure installation which is affected by a higher oxygen content due to normal swell or tidal movement

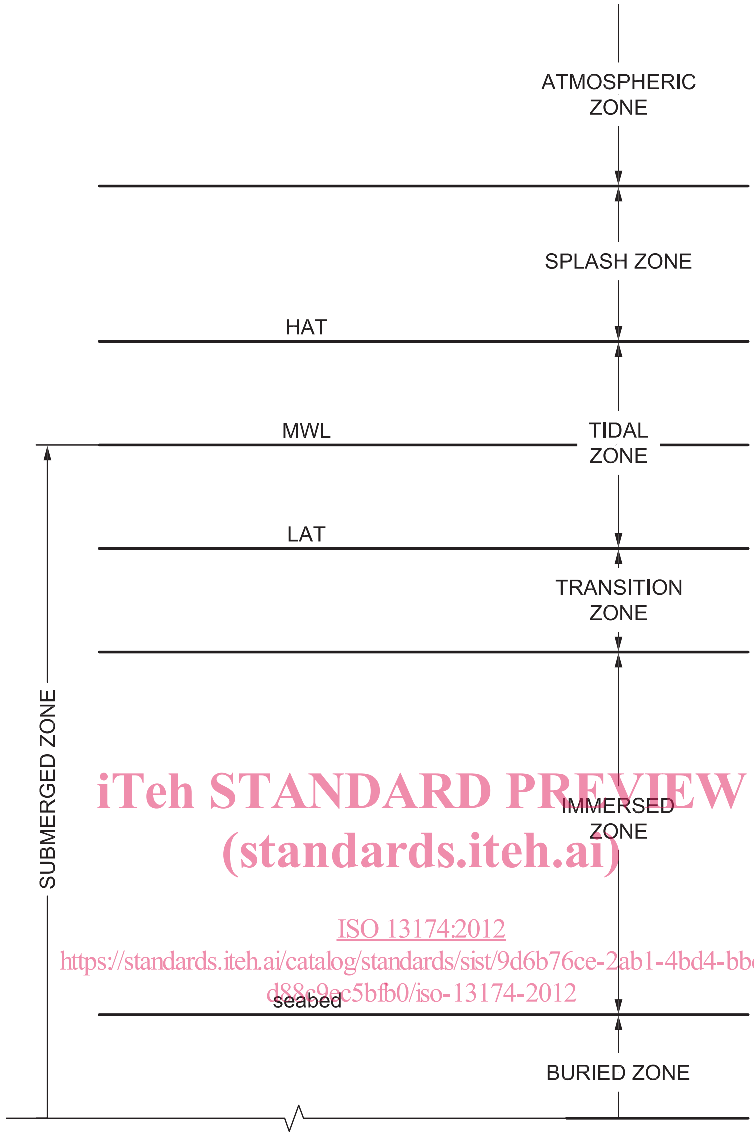

Figure 1 — Schematic representation of levels and zones in seawater environment

4 Competence of personnel

Personnel who undertake the design, supervision of installation, commissioning, supervision of operation, measurements, monitoring and supervision of maintenance of cathodic protection systems shall have the appropriate level of competence for the tasks undertaken. This competence should be independently assessed and documented.

NOTE 1 EN 15257 constitutes a suitable method of assessing and certifying competence of cathodic protection personnel which may be utilized.

NOTE 2 Competence of cathodic protection personnel to the appropriate level for tasks undertaken should be demonstrated by certification in accordance with EN 15257 or by another equivalent prequalification procedure.

5 Design basis

5.1 Objectives

The objective of a cathodic protection system is to deliver sufficient current to each part of the structure and appurtenances and to distribute this current so that the steel/water potential of each part of the structure is within the limits given by the protection criteria (see 5.2).

Steel/water potentials should be as uniform as possible over the whole structure. This may be achieved only if distribution of the protective current over the structure during normal service conditions allows. Uniform levels of cathodic protection may be difficult to achieve in some areas or parts of structures such as chains, for which a supplementary cathodic protection system may be considered if it is intended to attempt to provide full cathodic protection to them.

The cathodic protection system for a fixed or floating structure belonging to harbour installations may be combined with a coating system, even though some appurtenances, such as chains, may not benefit from the use of coatings. Extensive coating damage may also occur to buried areas of piles and steel sheet pile walls which are driven into position during installation.

Dielectric shields may be used in conjunction with anodes; particularly impressed current anodes, to minimize the risk of local over-protection and to improve the distribution of current from the anodes.

The cathodic protection system should be designed either for the life time of the structure or for a period corresponding to a planned maintenance or (if applicable) dry-docking interval. Alternatively when it is not feasible to design the cathodic protection system for the life of the structure or if dry-docking is not possible, the system should be designed for easy replacement of cathodic protection components, typically using divers or a ROV.

The above objectives should be achieved by the design of a cathodic protection system using impressed current or galvanic anode systems or a combination of both.

The design, the installation, the energising, the commissioning, the long-term operation and the documentation of all of the elements of cathodic protection systems shall be fully recorded.

Each step shall be undertaken in accordance with a fully documented quality plan.

NOTE ISO 9001 constitutes a suitable Quality Management Systems Standard which may be utilized.

Each stage of the design shall be checked and the checking shall be documented.

Each stage of the installation, energising, commissioning and operation shall be the subject of appropriate visual, mechanical and/or electrical testing and all testing shall be documented.

All test instrumentation shall have valid calibration certificates traceable to national or International Standards of calibration.

The documentation shall constitute part of the permanent records for the works.

5.2 Cathodic protection criteria

The criteria for cathodic protection are detailed in ISO 12473.

The criterion for protection of steel in aerobic seawater is a polarized potential more negative than −0,80 V measured with respect to silver/silver chloride/seawater reference electrode (Ag/AgCl/seawater reference electrode). This corresponds approximately to + 0,23 V when measured with respect to pure zinc electrode (e.g. alloy type Z2 as defined in EN 12496) or + 0,25 V when measured with respect to zinc electrode made with galvanic anode alloy types Z1, Z3 or Z4 as specified in EN 12496.

The criterion for protection of steel in anaerobic environments in seawater and sea bed muds which contain active sulfate reducing bacteria or support other microbial corrosion (MIC) species, including those associated with Accelerated Low Water Corrosion (ALWC), is a polarized potential more negative than −0,90 V measured with respect to silver/silver chloride/seawater reference electrode (Ag/AgCl/seawater reference electrode).

A negative limit of −1,10 V (Ag/AgCl/seawater reference electrode) is generally recommended to prevent coating disbondment and/or increase in fatigue propagation rates.

Where there is a possibility of hydrogen embrittlement of steels or other metals which may be adversely affected by cathodic protection to excessively negative values, an additional less negative potential limit shall be defined and observed. If not enough documented for a given material, this specific negative potential limit shall be determined relative to the metallurgical and mechanical conditions by mechanical testing at the limit polarized potential. For conventional steels, this limit is −1,10 V (Ag/AgCl/seawater reference electrode). Refer to ISO 12473 for more details.

These values also apply to steel in brackish waters but the errors due to variations in salinity when using Ag/AgCl/seawater reference electrodes shall be corrected when necessary as detailed in 6.3.4. The recommended metal/water potential limits for a range of metals and alloys in seawater are listed in ISO 12473.

NOTE The protection criteria and limit values are polarized potentials without IR errors. IR errors, caused by cathodic protection current flowing though resistive electrolyte and surface films on the protected surface, are generally considered insignificant in marine applications. Potential measurements using “Instant OFF” techniques or “coupon Instant OFF” techniques may be necessary in applications described in this International Standard to demonstrate the achievement of the above protection criteria (see EN 13509). Particular attention should be given to this in brackish waters and mud applications or close to impressed current anodes.

5.3 Design parameters

5.3.1 General

The design of a cathodic protection system should be made in order that each structure subdivision and anode zone is supplied with the cathodic protection current necessary to provide cathodic protection to meet the criteria in 5.2 for all service conditions.

5.3.2 Structure subdivision

Structures to be protected should be divided into different cathodic protection zones, which can be considered independently with respect to cathodic protection design, although they may not necessarily be electrically isolated.

NOTE 1 For a non-floating structure such as a dolphin, the area of piling can be divided into two main cathodic protection zones: the immersed or wetted cathodic protection zone and the buried cathodic protection zone. This division is related to the different current demands of the two zones. The high current demand of the immersed or wetted cathodic protection zone is due to the velocity of water movement, salinity, oxygen content and temperature. In the buried cathodic protection zone the current demand will be reduced due to the environment.

NOTE 2 For buoys, a single zone is generally considered sufficient to cover the immersed body of the buoy and the influenced part of the mooring chain(s).

5.3.3 Description of cathodic protection zone

Each cathodic protection zone may consist of several components, the parameters of which should be fully described including material (steel, cast iron, etc.), surface area and coating characteristics (type, lifetime and coating breakdown factor).

5.3.4 Service conditions

The design of the cathodic protection system(s) depends on service conditions which include lifetime, environment and operating conditions.

— Lifetime: Either the whole design life of the structure or the planned maintenance period(s) should be used.

— Environment: The seawater, sea bed, or estuarine environment properties to which the structure is exposed should be established (see ISO 12473 and Annex A).

— Operating conditions: The cathodic protection design normally considers only the static conditions of the structure because the durations when dynamic conditions prevail are generally negligible.

5.4 Electrical current demand

5.4.1 General

The current density for each component shall be selected to achieve the protection criteria specified in 5.2 for the conditions outlined in 5.3.

The current demand of each metallic component of the structure is the result of the product of its surface area exposed to the electrolyte multiplied by the selected current density (see Annex A).

5.4.2 Protection current density for bare steel

The selected current density may not be the same for all components of the structure as the materials, coatings, environment and service conditions may be variable.

The selection of design current densities should be based on experiences gained from similar structures in a similar environment or from specific tests and measurements.

NOTE 1 The current density depends on the kinetics of electrochemical reactions and varies with parameters such as the protection potential, surface condition, seawater resistivity, dissolved oxygen in seawater, seawater velocity at the steel surface, temperature.

For optimising the design, the following should be specified:

— initial current density necessary to achieve initial polarization of the structure;

— maintenance current density necessary to maintain polarization of the structure;

— final current density for possible repolarisation of the structure, e.g. after severe storms or cleaning operations.

NOTE 2 As the initial polarization preceding steady-state conditions is normally short compared to the design life, the average current density over the lifetime of the structure is usually very close to the maintenance current density.

If the structure has established ALWC or microbial corrosion the initial current density necessary for polarization may be greater than that necessary to polarize steel unaffected by microbial corrosion. In addition, the time to reach steady-state polarization may be considerably extended by the presence of previously active ALWC/microbial corrosion colonies. The design of cathodic protection of structures affected by ALWC shall take these factors into account (see Annex A).

The (average) maintenance current density shall be used to calculate the minimum mass of galvanic anode material or the capacity (anode current output x life) of impressed current anodes necessary to maintain cathodic protection throughout the design life. The initial or final current density values will normally determine the peak current output of the cathodic protection system; for galvanic anode systems the anode numbers and shape will generally be determined by these parameters and for impressed current systems the maximum output rating of anodes and power supplies will generally be determined by these parameters.