SLOVENSKI STANDARD
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Katodna zaščita zunanjih površin nadzemnih nosilcev skladiščnih cistern, ki so v stiku z zemljo ali temelji

Cathodic protection of external surfaces of above ground storage tank bases in contact with soil or foundations

Kathodischer Korrosionsschutz für erdberührte und gegründete Außenflächen von oberirdischen Lagertanks aus Stahl

Protection cathodique des surfaces externes des fonds de réservoirs de stockage aériens en contact avec le sol ou les fondations

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This European Standard was approved by CEN on 23 February 2013.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: Avenue Marnix 17, B-1000 Brussels

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Foreword

This document (EN 16299:2013) 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of an identical text or by endorsement, at the latest by October 2013, and conflicting national standards shall be withdrawn at the latest by October 2013.

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Introduction

It is important to maintain the integrity of above ground storage steel tanks (AST) for environmental and economical reasons.

This European Standard applies only for external corrosion prevention, which is independent of internal corrosion issues.

During the design of any new tank, a complete corrosion control study including the use of cathodic protection methods should be performed for preventing external corrosion of the surfaces in contact with soil, cushion or foundations. When cathodic protection is adopted, it is an effective method if designed, implemented, operated and maintained in accordance with this standard. The pre-requisites for the cathodic protection should be taken into account from the basic design. In case cathodic protection is not adopted, a documented technical justification on the equivalent effectiveness of alternative methods should be given.

For existing tanks, corrosion risks of external surfaces of tank bottoms may be important and possibly cause leaks, depending on the nature of soil, cushion, foundations, design of tank, and other equipment electrically connected to it such as an earthing system. Depending on the design and environmental conditions of the tank as detailed in the present standard, cathodic protection may be effective to mitigate corrosion when designed, implemented, operated and maintained in accordance with this standard.

Cathodic protection is aimed at supplying a direct current (d.c.) to the steel surface such that the steel-to-electrolyte potential is lowered to values where corrosion becomes insignificant.

Cathodic protection of above ground storage steel tanks is normally used in combination with a compatible protective coating system to protect the external surfaces of above ground storage steel tank bottoms from corrosion.

1 Scope

This European Standard defines the conditions necessary for an effective application of the cathodic protection method to mitigate corrosive attacks on the external surfaces of above ground storage steel tank bottoms in contact with soil, cushion or foundations.

This European Standard specifies the requirements for the design, implementation, commissioning, operation and maintenance of such a cathodic protection system.

This European Standard applies both for new and existing tanks.

NOTE 1 This European Standard is not applicable to reinforced concrete above ground storage tanks for which EN ISO 12696 applies.

NOTE 2 Detailed information concerning measurement techniques of cathodic protection given in EN 13509 are referred to in the present standard.

NOTE 3 Cathodic protection of internal surfaces of above ground storage steel tanks storing waters is addressed in EN 12499.

NOTE 4 Cathodic protection of external surfaces of buried tanks is addressed in EN 13636.

2 Normative references

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

EN 13509, *Cathodic protection measurement techniques*

EN 14015, *Specification for the design and manufacture of site built, vertical, cylindrical, flat-bottomed, above ground, welded, steel tanks for the storage of liquids at ambient temperature and above*

EN 14505, *Cathodic protection of complex structures*

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

EN 60079-0, *Explosive atmospheres — Part 0: Equipment — General requirements (IEC 60079-0)*

EN 60079-1, *Explosive atmospheres — Part 1: Equipment protection by flameproof enclosures "d" (IEC 60079-1)*

EN 60079-2, *Explosive atmospheres — Part 2: Equipment protection by pressurized enclosures "p" (IEC 60079-2)*

EN 60079-5, *Explosive atmospheres — Part 5: Equipment protection by powder filling "q" (IEC 60079-5)*

EN 60079-7, *Explosive atmospheres — Part 7: Equipment protection by increased safety "e" (IEC 60079-7)*

EN 60079-10-1, *Explosive atmospheres — Part 10-1: Classification of areas — Explosive gas atmospheres (IEC 60079-10-1)*

EN 60079-11, *Explosive atmospheres — Part 11: Equipment protection by intrinsic safety "i" (IEC 60079-11)*

EN 60079-14, *Explosive atmospheres — Part 14: Electrical installations design, selection and erection (IEC 60079-14)*

EN 60079-15, *Explosive atmospheres — Part 15: Equipment protection by type of protection "n" (IEC 60079-15)*

EN 60079-18, *Explosive atmospheres — Part 18: Equipment protection by encapsulation "m" (IEC 60079-18)*

EN 60079-25, *Explosive atmospheres — Part 25: Intrinsically safe electrical systems (IEC 60079-25)*

EN 60587, *Electrical insulating materials under severe ambient conditions — Test methods for evaluating resistance to tracking and erosion (IEC 60587)*

EN 61558-1, *Safety of power transformers, power supplies, reactors and similar products — Part 1: General requirements and tests (IEC 61558-1)*

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN ISO 8044 and EN 14015 and the following apply.

3.1
cushion
material in contact with the bottom of an aboveground storage tank

3.2
foundations
buried construction aimed at mechanically supporting locally the above ground storage tank

3.3
hazardous area
area in which an explosive atmosphere is present, or may be expected to be present, in quantities such as to require special precautions for the construction, installation and use of equipment

Note 1 to entry: For the purposes of this standard, an area is a three-dimensional region or space.

3.4
IR drop
voltage that is the product of all currents flowing through the cathodic protection circuit and the resistance of the current path (mainly the electrolyte and the tank bottom)

Note 1 to entry: This is derived from Ohm’s law (U = I x R).

3.5
IR free potential
polarised potential
structure to electrolyte potential without the voltage error caused by the IR drop due to the protection current or any other current

3.6
local earthing system
local earthing system for the structure under consideration which is electrically separated from any other general earthing

3.7
shield
conductive or non conductive structure or object, which modifies the protection current distribution on a structure to be protected

4 Abbreviations and symbols

API American Petroleum Institute

AST Above ground storage tank

E Potential

R Resistance

a.c. Alternating current

d.c. Direct current

E_{Cu} Metal or structure to electrolyte potential with respect to a copper/saturated copper sulphate reference electrode

E_{H} Metal or structure to electrolyte potential with respect to a normal hydrogen reference electrode

$E_{IR\ free}$ IR free potential

E_{cor} Free corrosion potential

E_{off} OFF potential

E_{on} ON potential

E_{p} Protection potential

HVDC High Voltage Direct Current

IEC International Electrotechnical Commission

MMO Mixed Metal Oxides

T Temperature

t Thickness of cushion

ρ Resistivity

5 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.

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

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.

6 Corrosion risks and their prevention by cathodic protection

6.1 General

The corrosion rate of a metal in soil or water is a function of the potential, E, of the material in its surrounding electrolytic environment. The corrosion rate decreases as the potential is shifted in the more negative direction. This negative potential shift is achieved by feeding direct current from anodes via the soil or water to the metal surface of the structure to be protected. In the case of coated structures, the current mainly flows to the metal surface at coating pinholes and holidays. The protection current can be provided by impressed current systems or galvanic anodes.

The corrosion risks and the need and feasibility of cathodic protection for a given above ground storage tank are directly linked to the mechanical design of the storage tank bottoms and to its environment.

The cushion material in contact with the tank has a significant effect on external corrosion of the tank bottom and can influence the effectiveness and applicability of external cathodic protection.

During the design of any new tank, a complete corrosion control study including the use of cathodic protection shall be performed. In case cathodic protection is not adopted, a documented technical justification on the equivalent effectiveness of alternative methods shall be given.

Cathodic protection is an effective method of corrosion prevention if electrical protection current reaches the whole surface of the tank bottom. Factors that may reduce or prevent the flow of current are:

— concrete foundations (shielding effect depending on anode location);

— asphalt or oiled sand made cushions;

— impervious membranes (depending on anode location);

— new tank bottoms installed above the original tank bottom and therefore not in contact with the cushion;

— excessive current demand caused by external structures such as earthing networks, especially when made of bare copper, and contact with steel reinforcement;

— interference from foreign cathodic protection systems;

— trapped air between the tank bottom and the cushion.

6.2 Corrosion risks of external surfaces of above ground storage tank bottoms in contact with soil or foundations

6.2.1 General

The external bottom of a tank is in contact with the cushion and, therefore, just like any other structure in contact with an electrolyte, it is subject to corrosion. The major factors to consider for an assessment of the corrosive conditions are the corrosivity of the cushion in contact with the bottom, galvanic effects, differential aeration and environmental conditions.

The tank bottom is subjected to large load variations caused by loading and discharge of the tank. It is also subject to temperature changes with the seasons and the stored product. The tank bottom is flexible, if not well supported by the soil and/or the cushion, except at its periphery where it is very rigid due to the weight of the shell on the concrete ring foundation. To a lesser degree, some rigidity exists at the periphery of each plate due to overlapping and lap-welds. This can result in vertical motions with possible introduction of moist air, which promotes corrosion.

6.2.2 Cushion

The assessment of the corrosion risks shall be based on both the imported materials constituting the cushion and the native surrounding soil which can pollute the cushion by capillary action and can include:

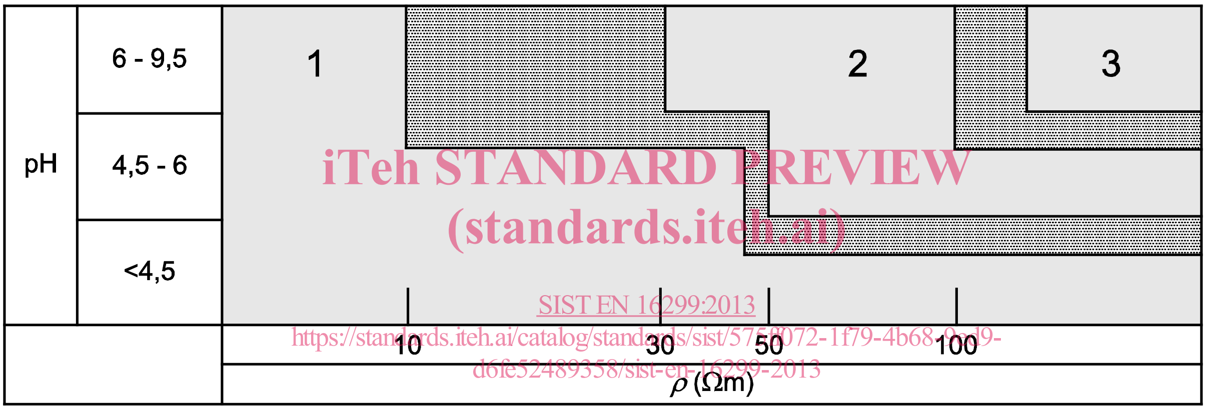
— the determination of the nature and hydrogeology of the area. These characteristics express the possibility of moisture and water flowing, or the ingress of air under the bottom of the tank;

— retention of precipitation in the bund area;

— resistivity measurements of the cushion and surrounding soil;

— likelihood of sulphate reducing bacteria development.

Soil conditions contributing to the so-called “corrosion load” (sum of all the effects on a steel structure due to a corrosive medium) are developed in EN 12501-1 and EN 12501-2. This standard enables classification of the risks of corrosion in three groups (low, medium and high “corrosion load”). It gives some guidance for assessing “corrosion load” from pH and resistivity of soil samples. Figure 1 reproduces Table 1 of EN 12501-2:2003 for pH less than 9,5.



Key
1 high
2 medium
3 low
ρ* Minimum resistivity value after adding deionised water (Ω.m)

Figure 1 — Corrosivity of soil (free corrosion without concentration cell from EN 12501-2:2003)

NOTE 1 API Standard 651 third edition [2] recommends the use of resistivity for a qualitative classification of soil “potential corrosion activity” as follows:

- resistivity < 5 Ω.m: very corrosive;
- resistivity from 5 Ω.m to 10 Ω.m: corrosive;
- resistivity from 10 Ω.m to 20 Ω.m: moderately corrosive;
- resistivity from 20 Ω.m to 100 Ω.m: mildly corrosive;
- resistivity > 100 Ω.m: progressively less corrosive.

NOTE 2 API Standard 651 second edition [1] related to chloride and sulphate concentrations: chlorides between 0,03 % to 0,1 % or sulphates between 0,1 % to 0,5 % were considered corrosive and chlorides higher than 0,1 % or sulphates higher than 0,5 % were considered very corrosive.

The ingress of moist air in the cushion at the peripheral areas increases the corrosion rate.

6.2.3 Galvanic effects

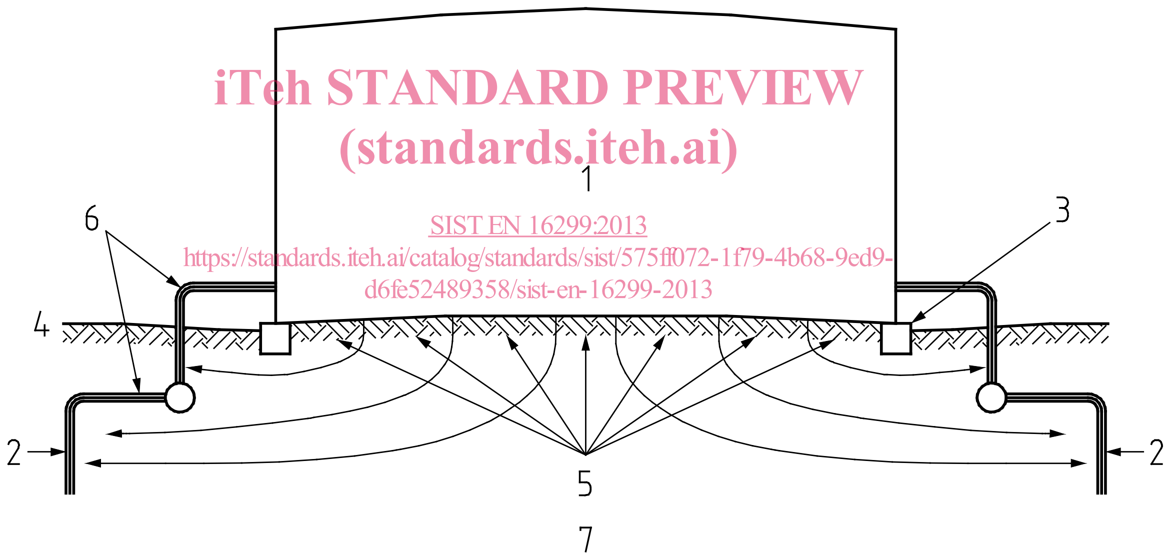
Galvanic cells can develop on the bottom of the tank itself due to different potentials between the steel of the plates and the weld metal, and possibly due to metallurgical differences in the metal of adjacent plates that make up the tank bottom.

The lower sides of the tank bottom are often coated with a bituminous solution. When this product is burnt during welding operations it can turn into conductive carbon particles, which will form a galvanic cell with the tank bottom.

Galvanic cells can exist if the tank is directly electrically linked to earthing systems made of copper or other metals or alloys such as stainless steels which are more cathodic than steel. The bottom surface can be corroded as illustrated in Figure 2.

Galvanic cells can exist if the tank is in contact with steel reinforcement of a concrete ring beam.

NOTE Generally, on new tanks, the presence of a waterproof plastic membrane spread out under the tank cushion before its construction minimises ingress of water or other contaminants from the native surrounding soil towards the cushion material and suppress, by shielding effect, galvanic cells caused by earthing systems. See 7.2.4 for more detailed information.



Key

1 above ground storage tank
2 cathode
3 concrete ring beam
4 soil
5 anodic area
6 bare copper earthing system
7 wet soil

Figure 2 — Galvanic corrosion of external surface of tank bottom due to coupling with copper earthing system

6.2.4 Stray currents

The presence of stray currents may result in local accelerated corrosion. When cathodic protection is applied, greater current requirements than those required under natural conditions may be necessary. Possible sources of stray current include dc operated rail systems and mining operations, other cathodic protection systems, welding equipment, and high-voltage direct current (HVDC) transmission systems. More details on risks and their mitigation are given in EN 50162.