Cathodic protection of buried metallic tanks and related piping

The European Standard EN 13636:2004 has the status of a British Standard

ICS 23.020.10; 77.060

British Standards

National foreword

This British Standard is the official English language version of EN 13636:2004. It partially supersedes BS 7361-1:1991, *Code of practice for land and marine applications*, which will be withdrawn when all the CEN standards relating to cathodic protection currently being prepared are published.

The UK participation in its preparation was entrusted to Technical Committee GEL/603, Cathodic protection, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this committee can be obtained on request to its secretary.

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the *BSI Catalogue* under the section entitled "International Standards Correspondence Index", or by using the "Search" facility of the *BSI Electronic Catalogue* or of British Standards Online.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 5 August 2004

Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 42, an inside back cover and a back cover.

The BSI copyright notice displayed in this document indicates when the document was last issued.

Amendments issued since publication

Amd. No.	Date	Comments

ISBN 0 580 44225 X

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 13636

July 2004

ICS 23.020.10; 77.060

English version

Cathodic protection of buried metallic tanks and related piping

Protection cathodique des réservoirs métalliques enterrés et conduites associées

Kathodischer Korrosionsschutz von unterirdischen metallenen Tankanlagen und zugehörigen Rohrleitungen

This European Standard was approved by CEN on 3 November 2003.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

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

Management Centre: rue de Stassart, 36 B-1050 Brussels

Ref. No. EN 13636:2004: E

Contents

Page

Foreword

This document EN 13636:2004 has been prepared by Technical Committee CEN/TC 219 “Cathodic protection”, the secretariat of which is held by BSI.

This document shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by January 2005, and conflicting national standards shall be withdrawn at the latest by January 2005.

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

This document, which deals with buried metallic tanks and associated piping, takes into account the specific features of buried tanks in terms of construction, electrical equipment and safety considerations.

The present document only covers the technical aspects of corrosion protection of tanks and associated piping. The application of cathodic protection depends on national requirements and the factors outlined in EN 12954:2001, Clause 5.

EN 12954, also prepared by CEN TC 219/WG1, is concerned with cathodic protection against corrosion of buried or immersed metallic structures and gives general principles applicable to the protection of all types of such structures.

Cathodic protection is a technique based on the application of electrochemical principles and covers a wide variety of materials and equipment together with a variety of measurement techniques. It is assumed in the drafting of this document that the design, installation, commissioning, inspection and maintenance are entrusted to adequately trained, experienced, competent and reliable personnel in order to achieve effective and efficient cathodic protection.

1 Scope

This document specifies the principles for the implementation of a system of cathodic protection against corrosive attacks on buried metal tanks and associated piping.

This document specifies conditions and parameters to be met in order to achieve cathodic protection, as well as rules and procedures for the design, installation, commissioning and maintenance for the protection of buried metal tanks and associated piping.

This document is applicable to the external surfaces of buried metallic tanks and associated buried piping.

NOTE The protection of internal surfaces is covered by EN 12499.

This document is applicable to buried tanks and associated piping, even if they are earthed by their own local earthing device, which are electrically separated from any general earthing systems and other buried structures.

Therefore tanks which are covered by the present document include:

- industrial storage tanks, irrespective of their dimensions and the nature of the stored medium (liquid or gas, flammable or not, toxic or non-toxic, polluting or not);
- tanks used at petrol stations and on domestic or commercial premises, which contain flammable liquids or gases or polluting substances.

This document is not applicable to:

- above-ground storage tank floors in contact with the ground;
- reinforced concrete containers;
- buried storage tanks that are electrically connected to the whole or a part of an industrial complex;
- buried storage tanks electrically connected to any general earthing systems.

NOTE Cathodic protection of the last two types of tanks is covered by prEN 14505.

Measurement techniques are described in detail in EN 13509.

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.

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

prEN 14505:2002, *Cathodic protection of complex structures*.

EN 50014, *Electrical apparatus for potentially explosive atmospheres — General requirements.*

EN 50016, *Electrical apparatus for potentially explosive atmospheres — Pressurized apparatus “p”.*

EN 50017, *Electrical apparatus for potentially explosive atmospheres — Powder filling "q".*

EN 50018, *Electrical apparatus for potentially explosive atmospheres — Flameproof enclosures "d".*

EN 50019, *Electrical apparatus for potentially explosive atmospheres — Increased safety "e".*

EN 50020, *Electrical apparatus for potentially explosive atmospheres — Intrinsic safety "i".*

EN 50021, *Electrical apparatus for potentially explosive atmospheres — Types of protection "n".*

EN 50028, *Electrical apparatus for potentially explosive atmospheres — Encapsulation "m".*

EN 50039, *Electrical apparatus for potentially explosive atmospheres — Intrinsically safe electrical systems "i".*

EN 50162:2003, *Protection against corrosion by stray current from direct current systems*.

EN 60079-10, *Electrical apparatus for explosive gas atmospheres — Part 10: Classification of hazardous areas (IEC 60079—10:1995)*.

EN 60742, *Isolating transformers and safety isolating transformers — Requirements (IEC 60742:1983 + A1:1992, modified)*.

EN 61140, *Protection against electric shock — Common aspects for installation and equipment (IEC 61140:2001).*

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

IEC 60587, *Methods for evaluating resistance to tracking and erosion of electrical insulating materials used under severe ambient conditions*.

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 12954, EN 60079-10, EN ISO 8044 and the following apply.

3.1
electrical connection (electrically connected)
connection allowing the flow of electrons between two different metallic structures

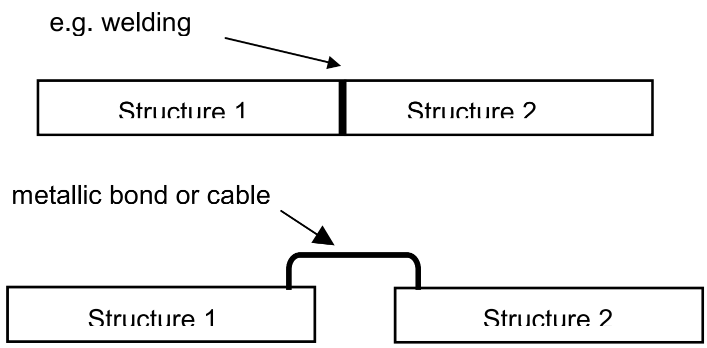


Figure 1 — Example of bonding permitting flow of current

3.2
electrical separation (electrically separated)
separation of two different metallic structures to prevent the flow of electrons between them

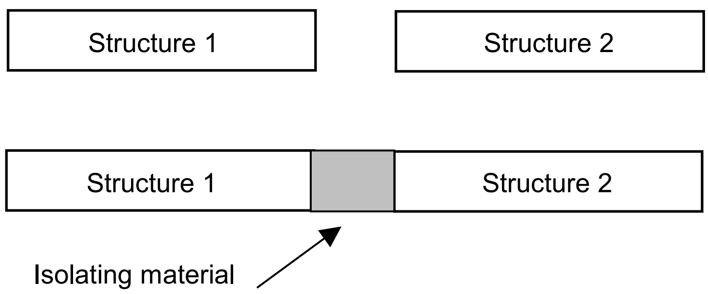


Figure 2 — Example of isolation to prevent the flow of currrent

3.3
associated piping
all metallic process piping that is electrically connected to a buried tank and is protected by the cathodic protection system of the tank

3.4
local earthing system
local earthing system for the structure under consideration which is electrically separated from any other general earthing

3.5
shield
conductive or non conductive structure or object, which modifies the protection current distribution on a structure to be protected

4 Criteria for cathodic protection

The metal to electrolyte potential at which the corrosion rate is < 0,01 mm per year is the protection potential, E_p. This corrosion rate is sufficiently low so that during the design lifetime corrosion damage cannot occur. The criterion for cathodic protection is therefore:

$$E \leq E_p$$

where

E is the metal to electrolyte potential

For carbon steel in soils with resistivities of ρ < 100 Ωm and in the absence of sulfate reducing bacteria, the protection potential versus a $Cu/CuSO_4$ saturated reference electrode, E_p,, is -0,85 V.

Special measures in accordance with EN 12954:2001, Table 1, shall be taken for steel with high yield strengths to avoid hydrogen-induced cracking.

NOTE 1 Full details of the principle and criteria of cathodic protection are given in EN 12954:2001, Clause 4.

NOTE 2 On well insulated tanks where the potential criterion is difficult to verify, the effectiveness of cathodic protection can be checked by measurement via a coupon (see 7.4.2).

5 Prerequisites for the application of cathodic protection

5.1 General

The different tank systems to be cathodically protected should be separate from each other.

NOTE 1 The separation distance depends on the diameter, the length and above all the average coating resistance of the tanks. It also depends on the location (close or remote) of the groundbed in relation to the cathodically protected structure.

NOTE 2 The design of cathodic protection for tank systems depends on the location and the extent of the structure, the kind of embedding material, the soil resistivity, the coating (type, coating resistance etc.) and also on general safety requirements.

For well-coated tanks the separation distance should be a minimum of 0,40 m between tanks.

The cathodically protected structure should be sufficiently remote from any other buried structure so that these foreign structures do not act as a shield for the structure to be cathodically protected and do not suffer from interference effects.

For well-coated tanks, the distance between cathodically protected and foreign structures should be a minimum of 1,0 m.

Where the tanks being cathodically protected are enclosed within steel reinforced concrete retaining walls, special attention shall be given to avoid:

a) detrimental effects of the cathodic protection currents upon the steel reinforcement;

b) metallic contact between the steel reinforcement and the tank.

NOTE Metallic contact between the steel reinforcement and the tank would reduce the current entering the tank.

5.2 Electrical continuity

The structure or a section of the whole structure to be cathodically protected shall be electrically continuous, with a low longitudinal resistance. The components which can increase the longitudinal resistance of the structure should be short-circuited, e.g. by using cables with a suitable cross-sectional area as described in 7.7.

Bonds should be capable of being temporarily disconnected for measuring purposes.

5.3 Electrical separation

Tanks to be cathodically protected shall have no metallic contact with:

a) parts of structures which are not to be cathodically protected;

b) earthed foreign structures (e.g. reinforcement steel);

c) general earthing systems even those made of galvanized steel.

When earthing is necessary for safety reasons (e.g. for electrical equipment, lightning and explosion protection) special measures shall be taken, as given in accordance with 7.2.3, 7.2.4 and 7.4.7.

5.4 External coating

The structure to be cathodically protected should normally be provided with an efficient external coating in order to:

a) provide sufficient corrosion protection;

b) reduce protection current demand;

c) improve current distribution; and

d) reduce interference to other foreign structures.

The coating should:

a) be compatible with cathodic protection; and

b) be resistant to the stored fluid.

NOTE In some cases, with structures comprising different metals, it can only be necessary to cover the more cathodic metal (see 7.1, Note a).

On structures which are bare or poorly coated, e.g. an existing tank, cathodic protection shall be applied with care to avoid electrical interference.

6 Base data for design

6.1 General

Structure details, local soil conditions, service conditions and the chosen design lifetime for the cathodic protection system should be established in order to choose the correct method of protection and the correct materials to achieve and sustain effective cathodic protection.

NOTE The design of effective cathodic protection systems is highly dependent upon correct information given by the owner or mandatory representative concerning the proposed structure to be protected.

6.2 Neighbouring structures

Details of neighbouring buried structures should be obtained. Such information should include as a minimum:

a) location (e.g. maps, detailed site layout);

b) principle dimensions and characteristics;

c) coating details;

d) type and location of any earthing system;

e) type and location of isolating devices;

f) details of foreign cathodic protection systems and/or other possible sources of stray current.

NOTE The use of such information can help to prevent adverse effects on the structure and on neighbouring structures.

6.3 Soil environment

Environmental conditions can have a major impact on the application of cathodic protection and should therefore be taken into account during the design phase.

The environmental conditions can include:

a) soil resistivities at suitable depths and locations;

b) presence of stray currents;

c) probability of sulphate reducing bacteria activity;

d) ground water level.

6.4 Tank and piping data

6.4.1 General

For the design of the cathodic protection of tanks and associated piping the following information should be available:

a) location of the structure;

b) structure materials and dimensions including surface area;

c) tank design (e.g. number of manholes, pits);

d) coating characteristics;

e) bedding details (method and materials);

f) earthing systems;

g) stored medium;

h) location and details of isolating devices;

i) location and details of sleeve pipes;

j) location and details of wall entries;

k) electrical equipment connected to the structures;

l) hazardous area classification in accordance with EN 60079-10;

m) existence of paved ground surface.

NOTE For existing tanks, the design may be based on the above information in conjunction with information gathered in field tests.

6.4.2 Stored medium

The physical and chemical characteristics of the medium in the tank and piping should be taken into account for the design and the selection of materials of the cathodic protection system.

Isolating joints used in the piping shall be selected taking into account the stored medium (corrosivity, conductivity, pressure, temperature etc.; see EN 12954:2001, 7.2).

7 Design and prerequisites

7.1 Structure materials

The protection potential $E\text{p}$ required shall be determined from the material(s) from which the structure is constructed in accordance with EN 12954:2001, 4.2 and Clause 4 of this document.

Where parts of the structure are made of different materials, the metals used shall be taken into account in the determination of the protection potentials and special measures can be taken in the design of the cathodic protection system.

NOTE Such measures may include:

a) increasing the resistance to earth by applying a suitable coating material to the metal with the more positive free corrosion potential, e.g. stainless steel, copper; or

b) installing permanent reference electrodes, coupons or external potential test probes close to the metal with the more negative free corrosion potential near its contact with the other metal to ensure that adequate potentials are obtained.

7.2 Electrical separation

7.2.1 General

Cathodically protected structures shall not be electrically connected directly to the general earthing system of the plant (see 5.3). Structures electrically connected directly to the general earthing system of the plant are classified as complex structures and shall be protected in accordance with prEN 14505.

7.2.2 Isolating devices

Electrical separation between the structure to be protected and structures which are connected directly to the general earthing system is obtained by means of isolating devices (e.g. isolating joints).

Isolating devices should be installed in such a way that accidental contacts of the isolated parts of the structure to the general earthing systems are avoided.

Isolating devices should be protected against damage caused by atmospherical and mechanical influences.

All isolating joints should be installed above ground.

For measurement purposes, all isolating joints should be easily accessible from both sides.

If buried, they shall be coated (see 8.3.3).

NOTE The requirements for isolating joints in hazardous areas are given in 7.3.3.

7.2.3 Temporary connections

As the electrical separation and consequently the cathodic protection can be disturbed due to temporary connections between the structure to be protected and trains, trucks or ships, the cathodic protection system shall be designed in such a way that it still functions properly after the disconnection.

7.2.4 Permanently connected electrical equipment

The installation of electrical equipment (e.g. pumps, electrically controlled valves, telemetric measuring devices) in the structure to be protected can affect the electrical separation between the structure and the general earthing system.

Depending on national regulations, separation can be achieved by:

a) the isolation of electrical equipment from the cathodically protected structure (as shown for example in A.1);

NOTE In this case the equipment is not protected by the cathodic protection system of the tank.

b) the use of electrical equipment of protection classes II or III as defined in EN 61140 (as shown for example in A.2);

c) the installation of a fault current breaker, if necessary in conjunction with a local earthing system (as shown for example in A.3);

d) the use of an isolating transformer (safe isolation, see EN 60742) (as shown for example in A.4);

e) the installation of d.c. decoupling devices between the electrical equipment and the general earthing system (as shown for example in A.5).

7.3 Explosion hazard prevention

7.3.1 General

Cathodic protection equipment and its installation in potentially explosive atmospheres shall conform to the requirements in EN 50014.

For the purposes of this subclause, the classification of the hazardous area (zones 0, 1 and 2) shall conform to EN 60079-10.

7.3.2 Electrical equipment installation

Installation of electrical equipment in zone 0 should be avoided.

If installed in zone 0, the equipment shall conform to EN 50020 and shall be of type ia.

In zone 1, explosion-proof electrical equipment or systems shall conform to one of the following documents:

a) EN 50016, for pressurized apparatus type “p”;

b) EN 50017, for powder filling type “q”;

c) EN 50018, for flameproof enclosure type “d”;

d) EN 50019, for increased safety type “e”;

e) EN 50020, for intrinsic safety type “i”;

f) EN 50028, for encapsulation type “m”;

g) EN 50039, for intrinsically safe electrical system type “i”.

In zone 2, the equipment shall conform to EN 50021 for non sparking type “n”.

7.3.3 Isolating joints

Isolating joints between cathodically protected and non-protected parts of the installation should not be placed in hazardous areas.

NOTE Attention is drawn to safety national regulations covering hazardous areas.

Isolating joints shall not be installed in zone 0, except if the zone 0 is located inside the pipe, in which case an isolating joint may only be installed if it is fitted with additional explosion hazard device (e.g. flame arrestor).

If isolating joints are installed in zone 1 and 2, they shall meet the requirement for use in the respective zone.

The design shall be such that accidental bonding is avoided.

To avoid sparks or flashover at isolating joints in zones 1 and 2, explosion-proof spark gaps should be installed.

NOTE Spark gaps are not required across isolating joints located inside petrol pump housings at service stations.

Isolating joints in a loading/unloading installation for flammable fluids shall only be installed on the fixed part of the piping installation.

7.4 Other equipment

7.4.1 Test station

A minimum of one test station shall be installed for each electrically isolated tank. Provisions shall be made for permanent cathodic protection measuring points, which are particularly important:

a) if the tank is placed under buildings;

b) if the tank is buried under isolating layers, e.g. asphalt, sealed concrete;

c) if the tank is installed at ground level and subsequently covered with a mound of earth (mounded vessel);

d) if several tanks are closely parallel;

e) if the tank has a large surface area.

In cases where isolating layers are provided for groundwater or soil protection, the design of the measuring point shall be such that ingress of polluting substances is avoided.

The number and location of fixed measuring points with or without a permanent reference electrode should be sufficient to ensure that the cathodic protection potentials measured are representative of the entire structure.

The number and location of measuring points depend on the different sizes and configurations of tank installations.

Recommendations concerning measuring points should be:

1) at least one measuring point for each tank,

2) at least two measuring points for each tank with a surface area of more than 20 m^2 and less than 100 m^2;

3) one additional measuring point for every 100 m^2 up to 500 m^2;

4) one additional measuring point for every 500 m^2 thereafter.

For measurement purposes, all isolating joints should be easily accessible from both sides.

If the isolating joints are not accessible, they shall be provided with a test station.

Measuring points and, if necessary test stations, shall be defined along the piping, at least at the ends and near critical points (e.g. sleeve pipe).

NOTE The number of test stations to be installed on the pipework depends on the length and geometrical arrangement of the piping.

To facilitate fault location, the installation of the structure and the cathodic protection system should be carried out in such a way that each part of the structure (tank, pipes, local earthing devices, etc.) can be electrically separated.

Bonds, which are to be temporarily opened for measurement reason shall be placed above ground.

7.4.2 Coupons

If polarization cannot occur, a 1 cm^2 to 10 cm^2 steel coupon should be connected to the structure.

NOTE 1 If the quality of the coating is very high and there is no metal in contact with the electrolyte, polarization cannot occur.

NOTE 2 In this way conventional cathodic protection measurements can be made on the coupons to show whether the respective size of a possible coating defect on the tank can be cathodically protected.

Coupons should be connected via a test station.

7.4.3 Mechanical connections including flanges

Mechanical connections, other than isolating joints, which can cause an unacceptable increase in the longitudinal resistance of the structure shall be electrically bonded.

7.4.4 Sleeve pipe

Sleeve pipes should be avoided where possible, unless required by national regulations, in which case special precautions should be taken in accordance with EN 12954:2001, 7.5.

7.4.5 Wall entries

Where entries are made through concrete structures, metallic contact between reinforcing steel and the protected structure shall be avoided in accordance with EN 12954:2001, 7.6.

A flawless coating shall be applied to the structure and special care shall be taken to avoid coating defects.

7.4.6 Drainage station

In areas where d.c. stray current can be present, the need for installing drainage station should be taken into account (see also EN 50162).

7.4.7 Local earthing systems

Where earthing is required for safety reasons, a local earthing system (see 3.5) should be installed.

The local earthing system should be made of a metal with a more negative free corrosion potential than the metal to be protected. For carbon steel tanks, zinc, galvanized steel or magnesium should be used as a local earthing material, but copper, stainless steel, or reinforcing steel in concrete should not be used.

To enable accurate measurements (current, earthing resistance, and potential measurements) to be made, it should be possible to temporarily disconnect this local earth connection.

NOTE Attention is drawn to safety regulations regarding earth connections.

7.5 Galvanic anode systems

7.5.1 General

Cathodic protection using galvanic anodes can be obtained economically if:

a) the current requirement is low;

b) the soil has a low resistivity.

Galvanic anodes are usually installed in a low-resistivity and non-carbonaceous backfill.

To meet the cathodic protection criteria, the following should be taken into account:

1) use of an efficient protective coating on the tank and piping;

2) maintain a good isolation between the structure to be protected and the neighbouring structures such as sleeve pipes, wall entries and foreign structures;

3) avoid the use of bare buried wires (e.g. for making connections to the earthing system).

7.5.2 Materials

Magnesium and zinc can be used as galvanic anode materials. Zinc anodes have a lower capacity and a smaller driving voltage against carbon steel than magnesium anodes. The choice between magnesium and zinc also depends on design life requirements and economic considerations.

7.5.3 Location

The location of the galvanic anodes depends on the structure to soil resistance and should be selected such that the desired current distribution can be achieved.

In general, anodes are located at a distance of at least 1 m from the structure.

NOTE 1 A low structure to soil resistance requires a larger distance between galvanic anode and structure.

NOTE 2 Additional measures may be taken as necessary to prevent accidental contact between the anodes and the structure to be protected.

7.5.4 Connection of anodes to the structure

To check the efficiency of the galvanic anode system, it shall be connected to the structure via a test station.

For functional checks, each anode should be connected separately to the test station.

7.6 Impressed current systems

7.6.1 General

Impressed current cathodic protection can be applied to buried metallic tanks and associated piping.

7.6.2 Components

7.6.2.1 Anode materials

Anode materials commonly used are:

a) silicon iron alloys;

b) graphite;

c) mixed metallic oxides;

d) conductive polymers;

e) steel.

The selection of the anode material depends on the individual application.

NOTE Further information on anode types and their materials is given in B.3.

7.6.2.2 Transformer rectifiers

The transformer rectifiers shall be rated for the anticipated current output until the end of the chosen design lifetime of the cathodic protection system and in accordance with safety rules as specified in EN 60742 and operating conditions in accordance with EN 50014.

The transformer rectifier specification should take account of monitoring requirements (e.g. remote control, output control) and the site location.

NOTE Attention is drawn to local safety regulations.

7.6.2.3 Groundbeds

The number, size and position of the anodes and the extent of the groundbeds should be selected so that:

a) they correspond to the chosen design lifetime for the cathodic protection system;

b) the desired current distribution can be achieved without adverse interference on foreign structures.

For deep well and shallow groundbeds located remotely from the tank see Annex B and EN 12954.

For a distributed anode system on buried cylindrical tanks and associated piping the anodes should be installed at or below the axis of the tank.

For tanks originally constructed above ground and subsequently covered with a layer of earth (mounded vessels), anodes should be distributed to achieve full cathodic protection for all soil conditions.

The anodes should be placed in a suitable low resistive backfill, e.g. electrically conductive coke.

The distance between the anodes and the protected structure should be at least 1 m. Between the anodes and foreign structures, the distance depends on the driving voltage and the soil resistivity, but should be large and at least 2 m.

7.7 Cables

Insulated cables should be used.

Minimum cable cross-sections should be as specified in EN 12954:2001, 7.11.3.

Impressed current system:

cable to protected structure:	10 mm^2 Cu
cable to groundbed:	4 x 2,5 mm^2 or 10 mm^2 Cu

Galvanic anode system:

cable to protected structure:	4 mm^2 Cu

cable to single anode: 2,5 mm^2 Cu

Test station:

cable for potential measurement: 2 x 2,5 mm^2 or 6 mm^2 Cu

cable for continuity bond : 4 x 2,5 mm^2 or 10 mm^2 Cu

In general, the cable size should be determined by the permissible ohmic resistance in the specific cable run.

NOTE 1 Attention is drawn to electrical and safety regulations governing cables.

NOTE 2 When current requirements are very small, selection of the conductor cross-section should be based upon mechanical strength rather than electrical resistance. Adequate mechanical protection can be used if the cables and their connections are brittle.

7.8 Interference

Any possible interference on the structure to be protected depends on the extent of the structure and the proximity of possible sources of stray current, e.g. d.c. traction systems, neighbouring cathodic protection systems. The adverse effects of stray d.c. current interference and measures to reduce this interference are detailed in EN 50162:2003 (extracts in Annex C).

The level of interference on foreign structures caused by a cathodically protected structure depends mainly on the output current of the anodes and on the distance between the anodes and the foreign structures.

To minimize the risk of interference on foreign structures, one or more of the following measures should be taken:

a) the rectifier output voltage and the anode current output should be minimized;

b) the distance between the foreign structure and the nearest anode should be increased.

NOTE The measures listed above only cover the anodic part of the protection system. Interference can also occur on nearby foreign structures close to bare parts of the protected structure (e.g. coating defects) where a significant voltage gradient may appear.

To prevent the occurrence of interference on nearby foreign structures close to bare parts of the protected structure, other measures should be taken in accordance with EN 50162.

8 Installation of cathodic protection systems

8.1 General

Installation of the cathodic protection system shall be carried out in accordance with the design based on the prerequisites detailed in Clause 7, which includes the location and installation of test stations and galvanic anodes, impressed current systems and drainage stations.

The other equipment determined by the design, such as isolating joints, coatings, sleeve pipes and local earthing devices, are integral parts of the structure to be protected and shall therefore be installed at the same time as the main structure to be protected.

The cathodic protection system should be installed as soon as possible, preferably during the burial of the tanks and the pipework.

Before the beginning of the work, it shall be verified that:

a) the equipment and the materials to be installed are in conformity with those indicated in the design;

b) the local conditions are the same as those used for the design.

Deviations from the design shall be justified for approval, then documented and later reported in as-built documentation.

The explosion hazard prevention measures mentioned in 7.3 shall be taken.

If there is a risk that tanks can come into metallic contact with other structures (e.g. reinforcing steel, anchors), permanent electrical isolation should be ensured before backfilling.

NOTE For the installation and the materials used, attention is drawn to the appropriate regulations, including safety regulations.

8.2 Installation of cables

8.2.1 General

In all cathodic protection installations, cables shall be installed with great care to avoid damage to the insulation.

They should be run through non conductive ducts and be protected with sufficient depth of cover (e.g. 80 cm) and have warning tapes.

If cables in ducts pass through hazardous areas, the ducts shall be sealed by adequate means to prevent flammable liquids and gases from being carried into non-hazardous areas.

As far as possible, cable joints in the ground should be avoided.

The cable should be long enough to deal with ground settlements.

All cables should be run to above-ground junction boxes installed outside hazardous areas. Junction boxes in hazardous areas e.g. valve pits and dome shafts should be flameproof.

The cables shall be clearly identified, either by using different colours or by identification marks.

NOTE Attention is drawn to the electrical and safety regulations governing cables.

8.2.2 Cable connections to structures

Cables bonding different parts of the structure to be protected should be accessible and allow disconnection.

Cable connections to foreign structures shall be agreed with the owners of those structures.

The cables should be connected to the structure at points where they are unlikely to be damaged during operation or maintenance.

Cable connections to the structure to be protected should be made by welding, brazing, bolts or conductive adhesives.

Cable connections to the structure to be protected shall be protected against corrosion (e.g. by coating).

Conductive epoxy should not be used for current carrying connections on impressed current systems.

For screwed connections and cable lugs, bolts of at least size M8 which are protected against self-loosening shall be used. All cable connections shall be low resistance.

The cable connecting procedure used should be such that it does not affect the mechanical properties of the structure.

Cables used for carrying current should not be used for measuring potential. Separate measurement cables should be installed.

8.3 Installation of structures to be protected

8.3.1 Buried structures

Tanks and pipes should be embedded in a material that does not damage the coating (e.g. sand).

This material shall be free from electronically conducting constituents (e.g. metals, carbonaceous materials, metal oxides such as magnetite).

NOTE A homogeneous bedding material ensures good current distribution and avoids shielding.

8.3.2 Above-ground structures

Where an above-ground structure including any associated local earthing system cannot be separated from the protected structure, it shall be protected against accidental contact with structures connected to the main earthing system.

Vent pipes, for example, should be protected by placing them in a plastic sleeve or by applying a plastic coating.

Pipes leaving the ground shall be protected by a coating at the air/soil area.

If applicable, this part of the structure should be coated up to a height of 0,5 m.

8.3.3 Isolating joints

Isolating joints shall be designed for electrical, mechanical and chemical operating conditions and before installation shall be able to withstand a testing alternating voltage of 5 kV in accordance with IEC 60587 over a period of one minute.

To allow inspection, isolating joints, particularly of the insulated flange type, should not be buried.

Joints of all types, when buried, shall be coated with materials compatible with the structure coating and shall be fitted with test cables.

NOTE 1 Above-ground isolating joints installed in hazardous areas are covered by national safety regulations, which require special safety measures to be taken, e.g. the application of a protective coating to prevent accidental contact and the fitting of explosion-proof spark gaps to prevent flashover.

If there are several isolating joints in a confined area (e.g. in a dome shaft), measures should be taken to avoid accidental contact, e.g. by installing joints at the same level.

NOTE 2 If water enters a dome shaft containing isolating joints, electrolytic short-circuiting can occur, causing corrosion. This can be avoided by, for example, mounting the isolating joints at a high level or providing adequate water drainage to the shaft or pit.

8.4 Anodes

8.4.1 General

At the time of anode installation, the following shall be ascertained by reference to the design documents:

a) that the anodes are located in accordance with 7.5 and 7.6, particularly for what refers to the condition of the soil and its resistivity;

b) that there is no shielding between the anodes and the structure to be protected;

c) that there is no risk of unacceptable interference to other buried metallic structures (see 7.8).

The electrical circuit between the anodes and the structure should be left disconnected until the free corrosion potential has been measured (see 9.1).

8.4.2 Galvanic anodes

At the time of installation of galvanic anodes, checks should be carried out to ascertain, by reference to the design file (plans, specifications and procedures) whether or not the following points are covered:

a) the electrolyte condition and resistivity where the anodes are to be located corresponds to the design;

b) there is no isolating shielding between the anode and the structure to be protected;

c) if there is any risk of interference, corrective measures have been taken

d) anodes conform to the specifications;

e) for buried anodes, the anode backfill material used is the correct type for the anodes concerned, and that the homogeneous backfill mixture is evenly distributed around the anode;

f) the pre-packaged anodes have been thoroughly wetted before burial;

g) the electrical circuit between the anode and the structure has been left open at the test station until the commissioning (see Clause 9).

8.4.3 Impressed current anodes

The dimensions of the anodic mass should be checked to see if they correspond to those indicated in the design. The backfill, if any, should be checked to verify that;

a) it has been correctly prepared;

b) it is sufficient in quantity;

c) it is homogeneously distributed around the anode;

d) it meets the requirements of the project specification.

NOTE The last two points are of particular importance.

8.5 Impressed current station

8.5.1 Location

The impressed current station should be easily accessible and be protected against the effects of the environment and mechanical damage. It should be located outside hazardous areas or, alternatively, be of a type suitable for use in such areas (e.g. with a flameproof, pressurized or ventilated enclosure).

8.5.2 Electrical installation

The electrical equipment and its installation should ensure continuous operation (e.g. by means of an indicator).

NOTE Attention is drawn to electrical and safety regulations.

8.6 Test stations, measuring points and coupons

Test stations should be located in easily accessible places in accordance with 7.4.1, protected against the risk of damage (e.g. shocks) and set up in such a way as to make them easy to find. They should be located outside hazardous areas.

The number and location of fixed measuring points and coupons shall be verified according to the design.

8.7 Bondings and drainage stations

Connection devices between cathodically protected and foreign structures shall be easily accessible to all concerned parties.

Connection devices between cathodically protected and foreign structures should be protected against damage by environmental effects.

8.8 Labelling

For information and safety reasons appropriate labels should be attached to the main components of the systems, such as impressed current stations, drainage stations and test stations and the structure to be protected.

Depending on the place of installation and the type of structure protected, these labels should:

a) include safety signs concerning the dangers of electricity;

b) include hazardous area signs;

c) describe measures to be taken in case of failure;

d) give the name of the owner/operator of the system;

e) indicate that the cathodic protection system must continuously be on, unless work is being carried out on the protected structure;

f) include circuit diagrams.

All cables within test stations shall be clearly identified.

8.9 Installation checks

Underground components, including connections, shall be checked before covering with soil.

Deviations from the design shall be justified for approval, then documented and later reported on as-built documentation.

Checks for the verification may include:

a) installation of the galvanic anodes;

b) installation of the transformer/rectifier (design, anode and cathode cable connections and electric function);

c) installation of the groundbed with backfill;

d) cable laying, cable connections, cable marking, integrity of cable ducts;

e) installation of permanent measurement coupons;

f) installation of fixed measuring points;

g) test stations (placing, design and marking of measurement sockets).

NOTE For the installation and the materials used, attention is drawn to the appropriate regulations, including safety regulations.

8.10 As-built documentation

Electrical diagrams and site layout drawings shall be made for the cathodic protection system, showing the structure with its main components, the location and type of galvanic and impressed current anodes, the impressed current stations, test stations and isolating joints as well as nearby foreign structures.

9 Commissioning

9.1 Preliminary checking

Before a cathodic protection system is activated, care should be taken to check that all installations are in accordance with the design.

In particular, cable connections and safety measures (contact protection, lightning protection, explosion proofing) shall where necessary be checked.

D.C. connections to the transformer rectifier shall be checked for correct polarity.

Further, the following measurements may be made and the readings compared with the design requirements:

a) Resistance measurements:

   1) resistance against remote earth of the groundbed or the galvanic anodes;

   2) resistance between the structure to be protected and the groundbed or the galvanic anodes.

b) Electrical separation of the structures:

1) at isolating joints;

2) at metal sleeve pipes;

3) from the general earthing system (see 5.3).

c) Potential measurements:

1) free corrosion potential, E_n, of the structure;

2) interference due to suspected stray currents;

3) anode to electrolyte potential of galvanic anodes;

4) structure to electrolyte potential of nearby structures.

d) Measurement to determine the extent of any interference from or on foreign structures.

9.2 Start-up

Switch on the cathodic protection station and confirm that it is functioning correctly.

Adjust station settings to conform to the potential requirements in the design. If major deviations occur, ascertain the causes by measurement.

When necessary, connect galvanic anodes to the protected structure via a variable resistor for current limitation.

Next make the following measurements:

a) rectifier output voltage on the impressed current station;

b) protection current output;

c) on and off potential at all measuring points;

d) on potential and current flow from or to foreign electrodes;

e) possible a.c. or d.c. interference (see EN 50162).

If stray currents are present, make measurements to determine the interference level in order to achieve the full effectiveness of cathodic protection. Make these measurements both with and without the cathodic protection stations in operation.

In addition, make measurements on any nearby foreign structures to ensure that they are not adversely affected by the cathodic protection system installed in accordance with EN 50162.

9.3 Verification of the cathodic protection effectiveness

Once the protected structure has sufficient electrical ground contact and after a suitable polarization period, the effectiveness of cathodic protection shall be checked for conformity in accordance with Clause 4.

9.4 Determination of relevant measuring points

At the end of the commissioning measuring points that are relevant for further periodic structure measurements may be determined.

9.5 Commissioning documents

After the successful commissioning of the cathodic protection installations, the following shall be prepared:

a) as-built drawings of the structure and its geographical position and those of all neighbouring structures likely to be affected by the cathodic protection system (see 8.10);

b) cathodic protection design with as-built drawings and all details pertaining to the cathodic protection of the structure;

c) results of interference tests carried out on neighbouring structures;

d) details of equipment operation and adjustment and the results of all measurements carried out before and after commissioning;

e) a summary of the installation records with references to any materials used and/or installation work that were not covered by the design.

The final data are the basis for subsequent system checks to be performed on the structure and therefore shall be filed and retained.

10 Inspection and maintenance

10.1 General

Inspection and maintenance shall ensure the effectiveness of cathodic protection throughout the life of the structure. For this to be achieved, the required structure to electrolyte potential shall be maintained within the limits stated in the design by continuous operation and maintenance of the cathodic protection system.

Subsequent to commissioning (see Clause 9), the structure shall be inspected regularly in accordance with written procedures approved by the owner of the structure or by mandatory representative.

The procedures should be subject to review to reflect operating experience and new technology.

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

10.2 Inspection

10.2.1 General

The inspection of the effectiveness of applied cathodic protection is conveniently divided into two areas: equipment functional checks and structure measurements.

The measuring results and all other findings shall be recorded.

The results obtained shall be analysed by cathodic protection personnel with adequate theoretical and practical knowledge.

If any abnormalities are observed, the causes shall be investigated and appropriate action shall be taken.

NOTE Attention is drawn to national regulations regarding the checking of electrical safety.

10.2.2 Functional checks of equipment

Regular visual inspections of the installation (e.g. functioning of the rectifier, readings of indicators, accessibility of test stations, connections) should be made to check the functioning and the good working conditions of the cathodic protection equipment.

10.2.3 Structure measurements

The cathodic protection effectiveness shall be assessed by comparing measurement values with the protection criterion or reference values.

Measured values established at the time of commissioning as well as in subsequent years shall be used as reference values.

Depending on the structure (type, size) and the cathodic protection system, the following measurements should be carried out:

a) rectifier output voltage of impressed current station;

b) protective current;

c) on and off potential at relevant measuring points and coupons;

d) on potential and current requirements of foreign electrodes;

e) d.c. interference to or from foreign structures, if found to be necessary following modification or readjustment of the cathodic protection system (see EN 50162).

NOTE Additional measurements to those given above may also be carried out to gather information on any changes in the effectiveness of the cathodic protection. Such measurements may include (see 9.1):

1) resistance measurements;

2) electrical separation of the structures.

If there are indications that the cathodic protection is not fully effective throughout the structure, investigations should be carried out, appropriate corrective action taken to restore effective cathodic protection, and the measured values obtained then used as the new reference values.

10.2.4 Inspection intervals

10.2.4.1 Frequency of equipment functional checks

Unless telemetric methods are used and regularly verified, function checks should be carried out at the typical frequencies given in Table 1.

Table 1 — Frequency and nature of functional checks

Equipment	Frequency and nature of functional checks
Galvanic anode stations	According to the frequency of the structure measurements (see 10.2.4.2) or more frequently if required by operational conditions.
Impressed current stations	Every 3 months or more frequently if required by operational conditions.
Connections to foreign electrodes	Annually or more frequently if required by operational conditions.
Safety and protection devices	Annually or more frequently if required by operational conditions.
Test stations	According to the frequency of the structure measurements (see 10.2.4.2) or more frequently if required by operational conditions.

10.2.4.2 Frequency of structure measurements

The effectiveness of cathodic protection should be checked when changes are observed in the structure or the environment and in particular after construction work on or in the vicinity of the structure.

NOTE The period of time between two successive assessments of cathodic protection effectiveness is typically one year, but may be reduced or increased depending on the type and location of tanks, and the consequences of a leak.

To determine the suitable inspection frequency Table 2 and Table 3 shall be used. The period of time between two successive assessments of cathodic protection effectiveness shall not exceed three years.

NOTE The inspection interval may be reduced to accommodate requirements imposed by national authorities.

Table 2 — Selection of weight factors

Items	Weight factors [a]		
	Low	Medium	High
1. Complexity of cathodic protection system	0	3	6
2. Coating imperfections	0	2	4
3. Environmental conditions e.g. d.c. interferences	0	2	4
4. Susceptibility to damage by lightning or mechanical impacts	0	1	2
5. Risk of personal injury or risk of environmental pollution or damage to property that could be caused by leakage of stored medium	0	3	6
Additional information concerning the weight factor for each item is given in Annex D.			
[a] Only use the proposed numbers.			

Table 3 — Selection of inspection frequency from Table 2

Total weight of items	Inspection frequency
9 – 22	One year
5 – 8	Two years
0 – 4	Three years

10.2.5 Inspection report

The results of inspections shall be recorded and evaluated. These records shall be kept for a sufficient period of time to provide detailed information on the cathodic protection effectiveness and to allow comparative checks to be carried out.

In addition, records and the cathodic protection history should be kept for reference purposes for the lifetime of the structure.

10.3 Maintenance

10.3.1 Cathodic protection equipment

Routine maintenance shall be carried out in a way to ensure that the cathodic protection system continues to operate in the manner intended by the design.

Transformer rectifiers shall be maintained in accordance with the manufacturer's recommendations.

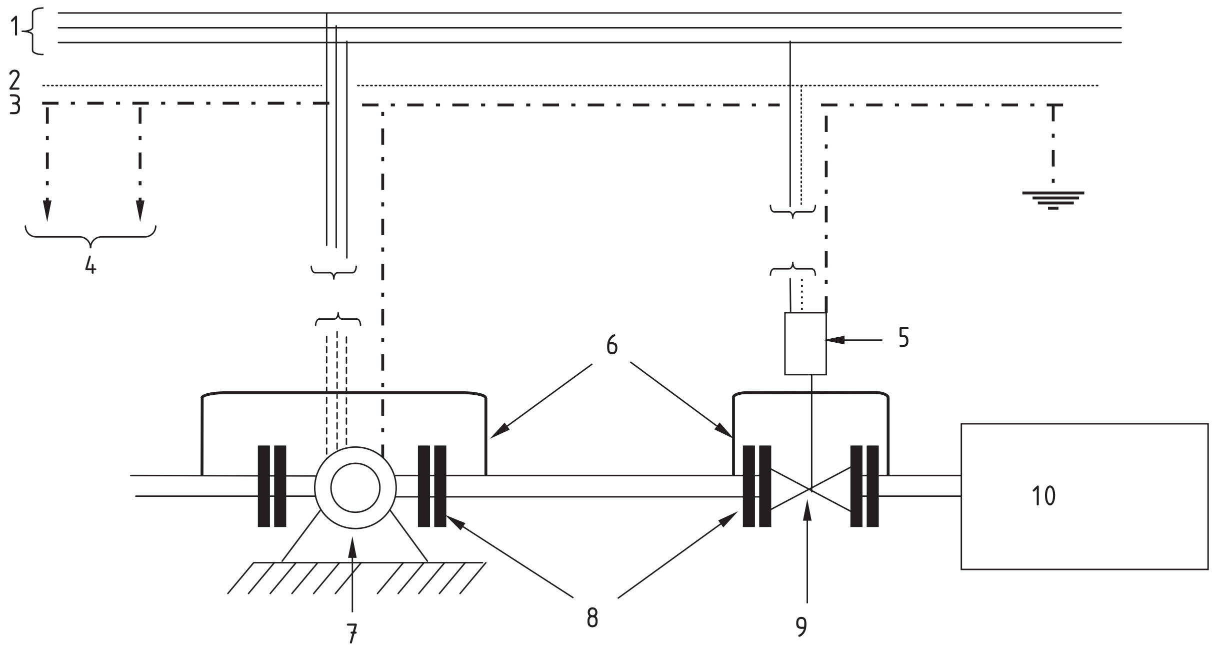
Maintenance on cathodic protection equipment should also be carried out when necessary during or as soon as possible after functional checks or structure measurements.

10.3.2 Instrumentation

Instrumentation (e.g. permanent reference electrodes, measuring and regulating devices, telemetry) shall be kept in good working order and shall be subjected to periodical calibration and safety checks.

Annex A
(informative)
Electrical separation between the structure to be cathodically protected and the general earthing system

A.1 Isolation of electrical equipment

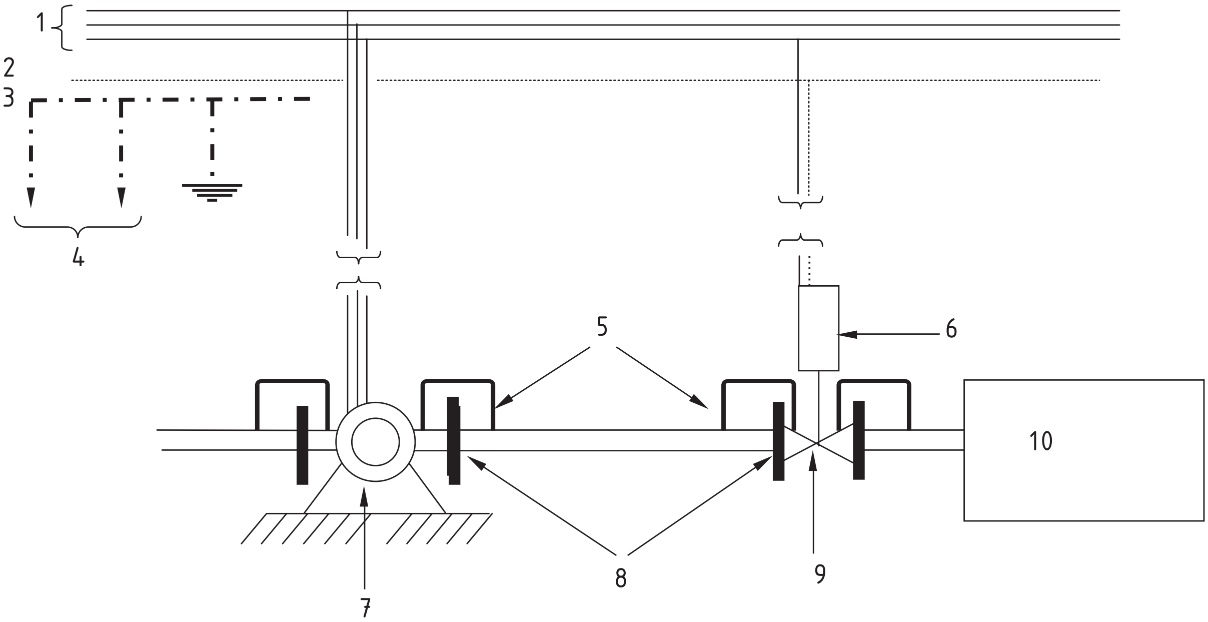


Key

1. Phases
2. Neutral
3. Protective ground/earth cable
4. Reinforcement in concrete, metallic structure without cathodic protection, earthing equipotential connection
5. Motor
6. Cable bonds
7. Electrical pump all structure connected
8. Isolating flanges
9. Electrical valve
10. Tank

Figure A.1 — Tank and associated piping with cathodic protection — Isolation of electrical equipment

A.2 Electrical equipment of protection class II or III (double isolation)



Key

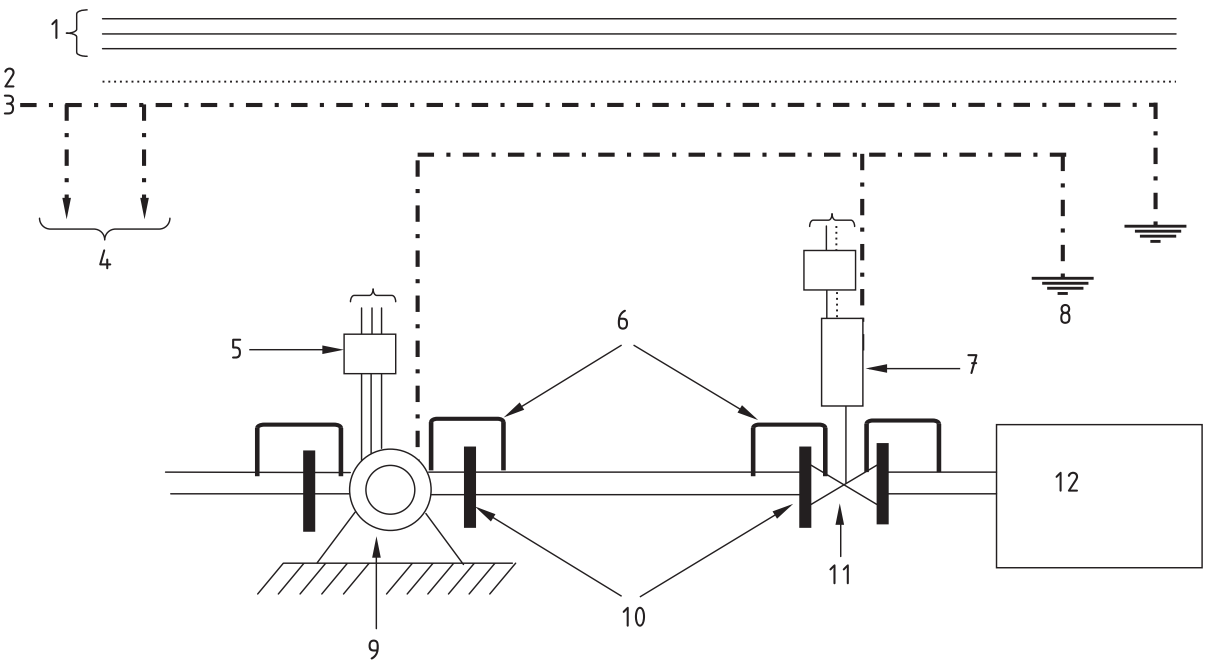
Key

1. Phases
2. Neutral
3. Protective ground/earth cable
4. Reinforcement in concrete, metallic structure without cathodic protection, earthing equipotential connection
5. Cable bonds
6. Motor with class II or III isolation
7. Electrical pump with class II or III isolation
8. Flanges
9. Electrical valve
10. Tank

The pump, motor and valve should be electrically isolated from rebar and all structures connected to the general earthing system.

Figure A.2 — Tank and associated piping with cathodic protection — Electrical equipment of protection class II or III (double isolation)

A.3 Fault current breaker with local earthing system



Key

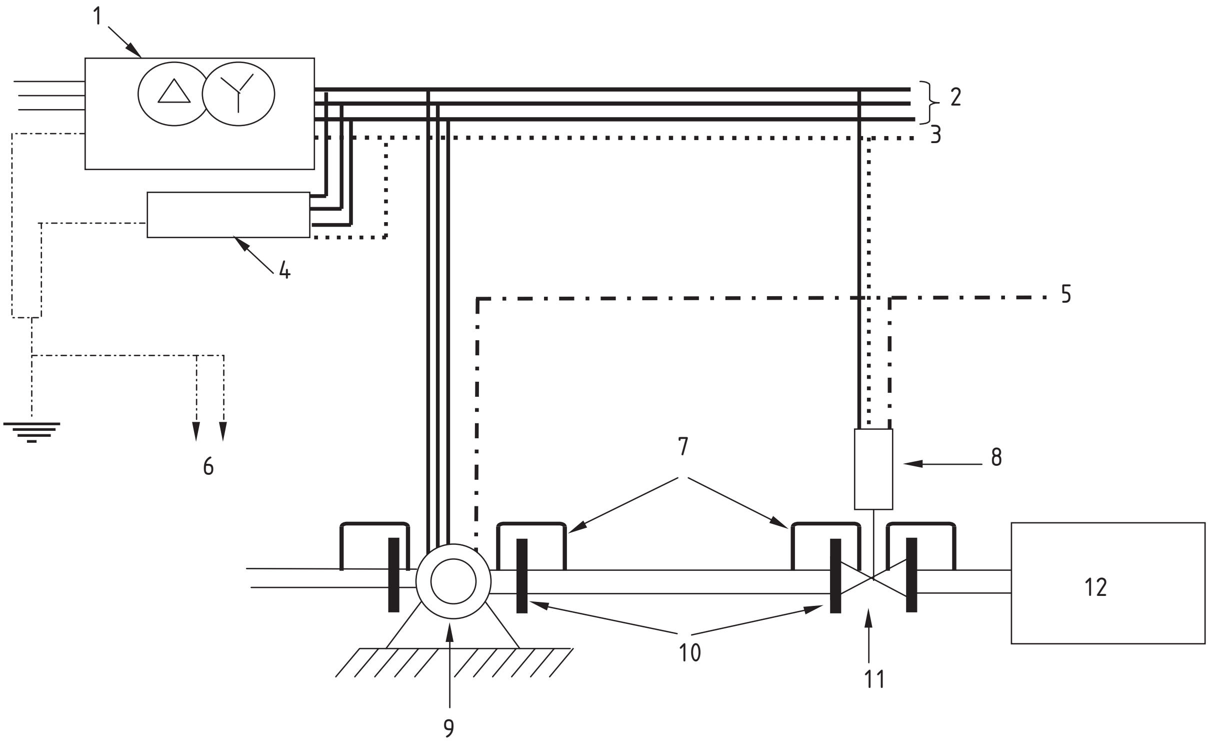
1. Phases
2. Neutral
3. Protective ground/earth cable
4. Reinforcement in concrete, metallic structure without cathodic protection, earthing equipotential connection
5. Fault current breaker
6. Cable bond
7. Motor
8. Local earth[a] (zinc, galvanized steel)
9. Electrical pump[b]
10. Flange
11. Electrical valve[b]
12. Tank

[a] Resistance of local earth < safety voltage/fault current (FI), e.g. Safety voltage = 50 V, FI = 300 mA, Re < 165 Ω ; e.g. safety voltage = 24 V, FI = 300 mA, Re < 80 Ω.

[b] The pump, motor and valve should be electrically isolated from rebar and all structures connected to the general earthing system.

Figure A.3 — Tank and associated piping with cathodic protection — Fault current breaker with local earthing system

A.4 Isolating transformer



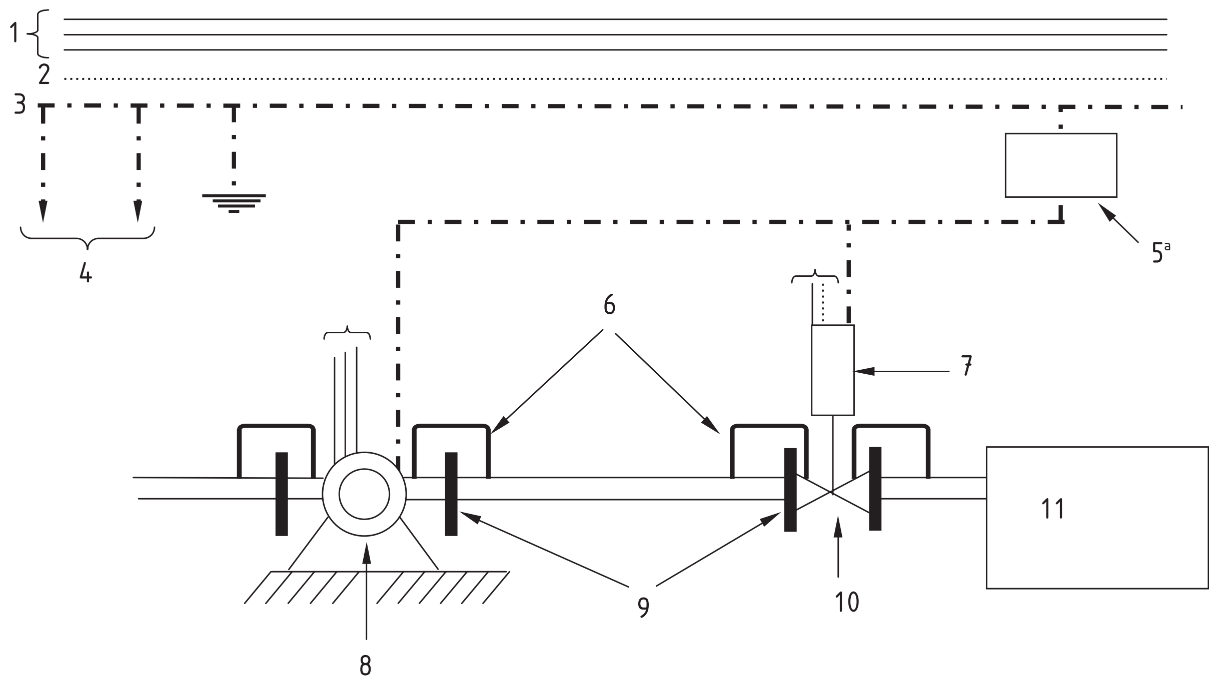
Key

1. Isolating transformer
2. Phase
3. Neutral
4. Isolation survey
5. Isolated cable for equipotential purposes
6. Reinforcement in concrete, metallic structure without cathodic protection, earthing equipotential connection
7. Cable bond
8. Motor
9. Electrical pump[a]
10. Flanges
11. Electrical valve[a]
12. Tank

[a] The pump, motor and valve should be electrically isolated from rebar and all structures connected to the general earthing system.

Figure A.4 — Tank and associated pipe with cathodic protection — Isolating transformer

A.5 Example with d.c. decoupling unit



Key

1. Phases
2. Neutral
3. Protective ground/earth cable
4. Reinforcement in concrete, metallic structure without cathodic protection, earthing equipotential connection
5. D.C. decoupling device[a]
6. Cable bond
7. Motor
8. Electrical pump[b]
9. Flange
10. Electrical valve[b]
11. Tank

[a] For safety reasons, , it is essential that the d.c. decoupling device ensures current flowing to the earths, in case of failure.

[b] The pump, motor and valve should be electrically isolated from rebar and all structures connected to the general earthing system.

Figure A.5 — Tank and associated pipe with cathodic protection — Example with d.c. decoupling unit

Annex B
(informative)

Groundbed data

B.1 General considerations

The application of cathodic protection to buried tanks and associated piping, as described in this document, usually needs particular configurations of the groundbeds. Sometimes a configuration with a remote located groundbed can be used, but more often a close located groundbed system is necessary.

In order to ensure suitable current and voltage outputs, it is essential that the earthing resistance of the anodes is carefully calculated and, where necessary, techniques are used to lower the groundbed resistance to earth.

When designing a groundbed system, it is important to take into account all factors that can affect the groundbed lifetime. In selecting groundbed sites and voltage output, care should be exercised to avoid interference to other structures. The presence of electrical shielding between the groundbed and the structure to be protected should be avoided.

B.2 Type of groundbed

B.2.1 General

For general description and characteristics of shallow and deep groundbeds reference should be made to EN 12954.

B.2.2 Remote located groundbed

A cathodic protection installation equipped with a remote located groundbed provides a wide distribution of the current all over the structure to be protected.

Generally, a deep well groundbed is often preferred over a shallow groundbed to provide better current distribution over the tank installation.

B.2.3 Close located groundbed

When a close located groundbed system is used, the anodes are placed close to the structure to be protected.

Close located groundbeds are of two types:

a) distributed groundbed, made of anodes that are generally placed throughout or along the major dimensions of the structure to be protected at short intervals;

b) continuous groundbed, which can be made using flexible wire anodes or anodes placed in a continuous carbonaceous backfill at suitable intervals.

With these two configurations, a uniform current distribution along the structure is provided, less overall current and voltage output is needed and shielding and interference problems are generally avoided.

Shallow groundbeds, both horizontal and vertical, are generally used.

Horizontal groundbeds are, if possible, installed as deep as the structure to be protected.

B.3 Anode type

B.3.1 High-silicon cast iron anodes

High-silicon cast iron alloys for anodes are of two types, with or without chromium.

The chromium free alloy can be used only in halide-free environment to avoid a too high consumption rate.

The high-silicon chromium cast iron alloy is suitable for all applications whatever is the halide content (e.g. sea water).

The use of high-silicon chromium cast iron anodes can be subjected to national limitations.

A typical material composition of high-silicon chromium cast iron anodes is given in Table B.1.

Table B.1 — Composition of high-silicon chromium cast iron anodes

Materials	**Contents** %
Silicon	14,20 to 14,75
Chromium	3,25 to 5,00
Carbon	0,70 to 1,10
Manganese	max. 1,50
Copper	max. 0,50
Molybdenum	max. 0,20
Iron	Balance

The performance of this material as a cathodic protection anode depends on the formation of a thin layer of silicon dioxide on the surface of the anode. This film is partially protective and its formation is not fully developed if the alloy contains less than 14,2 % of silicon and, in environments containing halides, less than about 4 % of chromium.

The most common anode shapes are cylindrical rods and tubes. These anodes are available both bare and pre-packaged with carbonaceous backfill inside steel canisters.

Underground applications include deep vertical, shallow vertical, or horizontal bed with or without backfill.

The consumption rates vary from (0,1 to 0,5) kg/A per year and depend on the alloy composition, the environment and the maximum current density applied, which can range from (10 to 50) A/m².

B.3.2 Mixed-metal oxide anodes

Mixed-metal oxide anodes consist of electrocatalytic active coatings on a high-purity titanium substrate.

The coatings usually consist of a mixture of highly conductive oxides. The titanium serves as a support for the oxides and is protected by a thin adherent film which resists the passage of current in the anodic direction. The oxide coating is the anode material.

The following anode shapes are mostly used:

a) tubular, both bare and pre-packaged in steel canisters filled with carbonaceous backfill;

b) wires and rods, usually in steel canisters with carbonaceous backfill;

c) mesh;

d) strips.

Mixed metal oxide anodes are suitable for applications in seawater, in freshwater, in mud and in soil, preferably in carbonaceous backfill.

The maximum current density ranges from (35 to 50) A/m^2 in freshwater to 100 A/m^2 in soil in carbonaceous backfill and to 500 A/m^2 in seawater.

Annex C
(informative)

Extract of EN 50162

(Note: The Clause numbers are the same as in EN 50162)

7.8.2 Adjustment of transformer rectifier output

The current output of the rectifier installed on an interfering structure shall be adjusted to the minimum level providing cathodic protection. In particular cases, the possibility of distributing the total current by additional rectifiers and groundbeds could be considered.

7.8.3 Increasing coating resistance

Structures with high quality coatings require less cathodic protection current and hence minimize stray current interference. Coating defects on a cathodically protected structure may need to be located and repaired if the level of interference to nearby structures needs to be reduced.

7.8.4 Groundbed location

The interference from impressed current anodes depends on the current output, distance to neighbouring structures, and the environment resistivity of the surrounding medium.

The interference can be reduced by ensuring that the neighbouring structures are not within the area of the anode field where the potential gradient causes the potential to shift outside the limits detailed. This can be achieved by:

— increasing the distance from the anode to neighbouring structures (either horizontally or vertically). This is the most effective method;

— reducing the voltage gradient around the groundbed by enlarging the groundbed geometry or by reducing the current output (see 7.8.2);

— locating distributed anodes close to the structure to be protected.

Annex D
(informative)

Determination of inspection interval

D.1 General

To determine an inspection interval, each weight factor as mentioned in 10.2.4.2 should be classified as “low”, “medium” or “high”.

In case of unclear identification the higher weight factor should be chosen.

D.2 Complexity of the cathodic protection system

Depending on the extent of a cathodic protection system and the object(s) to be protected a weight factor should be specified.

The weight factor is related to the number of tanks, geometry of object, surface to be protected, type of cathodic protection system (galvanic-anode or impressed current system), number of anodes, length of underground piping to be protected, etc. as shown in Table D.1.

Table C.1 — Weight factors for complexity of the cathodic protection system

Weight factor	Typical examples
Low	• Two galvanic anodes or impressed current system for one single tank and short piping
Medium	• A petrol station with three tanks and short piping
High	• A large mounded vessel • A tank with large surface, or high number of tanks • Long piping • A tank enclosed within a steel reinforced concrete retaining walls • Several tanks and piping coated with different coatings

D.3 Coating imperfections

Depending on the quality of the coating of the structure to be protected, a weight factor should be specified, as shown in Table D.2.

Table D.2 — Weight factors for coating imperfections

Weight factor	Typical examples
Low	• A coating without defect and fine embedding material (e.g. sand)
Medium	• A coating in good condition on the tank with poorly applied field coating on piping and spare parts
High	• A coating with large and numerous defects (e.g. bitumen, jute) • Inappropriate embedding material (e.g. soil with stones)

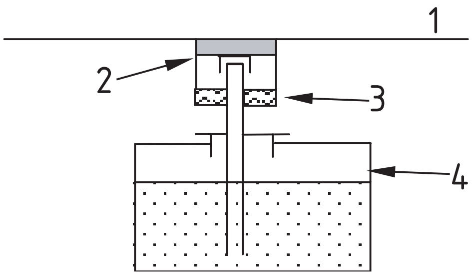
D.4 Environmental conditions

Depending on the type of the environment of the structure to be protected, a weight factor should be specified.

The weight factor is related to the surrounding soils, presence of groundwater, interfering d.c. sources, etc. as shown in Table D.3.

Table C.3 — Weight factors for environmental conditions

Weight factor	Typical examples
Low	• A homogeneous soil, no interfering d.c. source, no lower pit where rainwater is stored and more cathodic protection current is required (see Figure D.1).
Medium	• Different soil resistivities (clay/sand) • A partly submerged tank in groundwater • The ground level is polluted with de-icing salts • The distance from interfering d.c. sources is small (approximately 30 m or even less) with a total length of the structure under consideration greater than 10 m
High	• Combination of two “medium weight” examples • The distance from interfering d.c. sources is very small (approximately 10 m) or the total length of the structure under consideration is much higher than 10 m



Key

1. Ground level
2. Level measuring point in a pit
3. Water
4. Tank

NOTE Total length of the structure under consideration is lower than 10 m.

Figure D.1 — Risk of rainwater storage

D.5 Susceptibility to damage by lightning or mechanical impact

Depending on the susceptibility to damage by lighting or mechanical impact of the structure to be protected, a weight factor should be specified, as shown in Table D.4.

Table D.4 — Weight factors for susceptibility to damage by lightning or mechanical impact

Weight factor	Typical examples
Low	• A location without above ground piping • A location with a low probability of excavation
Medium	• A location with extended above ground piping
High	• A location with a high probability of excavation

D.6 Risk of personal injury, environmental pollution or damage to property that could be caused by leakage of stored medium

Depending on the risk of personal injury, environmental pollution or damage to property that could be caused by leakage of stored medium, a weight factor should be specified, as shown in Table D.5.

Table D.5 — Weight factors for risk of personal injury, environmental pollution or damage to property that could be caused by leakage of stored medium

Weight factor	Typical examples
Low	• One small LPG tank located in a rural area
Medium	• A petrol station in a rural area
High	• A petrol station in an urban area or along an highway • A petrol station in a shopping area • A tank filled with a polluting product in an extraction area for potable water

Bibliography

EN 12499, *Internal cathodic protection of metallic structures*.

EN 13509, *Cathodic protection measurement techniques*.

blank

BSI — British Standards Institution

BSI is the independent national body responsible for preparing British Standards. It presents the UK view on standards in Europe and at the international level. It is incorporated by Royal Charter.

Revisions

British Standards are updated by amendment or revision. Users of British Standards should make sure that they possess the latest amendments or editions.

It is the constant aim of BSI to improve the quality of our products and services. We would be grateful if anyone finding an inaccuracy or ambiguity while using this British Standard would inform the Secretary of the technical committee responsible, the identity of which can be found on the inside front cover. Tel: +44 (0)20 8996 9000. Fax: +44 (0)20 8996 7400.

BSI offers members an individual updating service called PLUS which ensures that subscribers automatically receive the latest editions of standards.

Buying standards

Orders for all BSI, international and foreign standards publications should be addressed to Customer Services. Tel: +44 (0)20 8996 9001. Fax: +44 (0)20 8996 7001. Email: orders@bsi-global.com. Standards are also available from the BSI website at http://www.bsi-global.com.

In response to orders for international standards, it is BSI policy to supply the BSI implementation of those that have been published as British Standards, unless otherwise requested.

Information on standards

BSI provides a wide range of information on national, European and international standards through its Library and its Technical Help to Exporters Service. Various BSI electronic information services are also available which give details on all its products and services. Contact the Information Centre. Tel: +44 (0)20 8996 7111. Fax: +44 (0)20 8996 7048. Email: info@bsi-global.com.

Subscribing members of BSI are kept up to date with standards developments and receive substantial discounts on the purchase price of standards. For details of these and other benefits contact Membership Administration. Tel: +44 (0)20 8996 7002. Fax: +44 (0)20 8996 7001. Email: membership@bsi-global.com.

Information regarding online access to British Standards via British Standards Online can be found at http://www.bsi-global.com/bsonline.

Further information about BSI is available on the BSI website at http://www.bsi-global.com.

Copyright

Details and advice can be obtained from the Copyright & Licensing Manager. Tel: +44 (0)20 8996 7070. Fax: +44 (0)20 8996 7553. Email: copyright@bsi-global.com.

BSI
389 Chiswick High Road
London
W4 4AL