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External cathodic protection of well casings

Äußerer kathodischer Korrosionsschutz von Bohrlochverrohrungen

Protection cathodique externe des cuvelages de puits

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Protection cathodique externe des cuvelages de puits

Äußerer kathodischer Korrosionsschutz von Bohrlochverrohrungen

This European Standard was approved by CEN on 19 June 2006.

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COMITÉ EUROPÉEN DE NORMALISATION
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Foreword

This document (EN 15112:2006) 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of an identical text or by endorsement, at the latest by January 2007, and conflicting national standards shall be withdrawn at the latest by January 2007.

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, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

Introduction

Gas, oil and water well casings are usually cemented for the proposes of anchoring the pipes in the borehole and isolating the various geological layers from each other. This is necessary to avoid liquid exchanges between these.

Steels in contact with the cement are in a passivation status and, thus, protected from any kind of external corrosion, except if the cement contains chloride ions. However, it is not always possible to obtain a continuous cementation on all the external steel surfaces. These bare residual surfaces may be in contact with more or less aggressive layers. Furthermore, these surfaces may constitute electrochemical cells with the cemented metallic parts. The anodic areas, which are the poor cemented parts, correspond to corrosion areas.

In general, external corrosion effects are rare, particularly on recent wells, since most of them are well cemented. However, borehole cementation programmes sometimes result in cementation failures, and studies have shown that, corrosion phenomena being progressive, the mean time for the appearance of leaks is dependent on different factors such as geological formation, thickness of the layers and of the steel casing.

Experience has also shown that the situation may be significantly improved by applying external cathodic protection to wells.

Environmental aspects with regard to gas, oil or water wells should be considered when deciding on whether or not to apply cathodic protection.

1 Scope

This European Standard specifies methods used to evaluate the external corrosion hazards of well casings, as well as cathodic protection means and devices to be implemented in order to prevent corrosion of the external part of these wells in contact with the soil.

This European Standard applies to any gas, oil or water well with metallic casing, whether cemented or not.

However, in special conditions (shallow casing: e.g. 50 m, and homogeneous soil), EN 12954 can be used to achieve the cathodic protection and assess its efficiency.

This European Standard also describes techniques allowing determination of the current required for protection and ensuring correct operation of the cathodic protection devices installed.

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*

EN 60079-10, *Electrical apparatus for explosive gas atmospheres — Part 10: Classification of hazardous areas (IEC 60079-10:2002)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 12954 and the following apply (see also Figure 1).

3.1
casing (or well casing)
heavy steel pipe string used to line a borehole from the ground surface, and secured in the formations generally by cementing

NOTE Casing is generally externally cemented over its total depth or over a length sufficient to obtain anchoring and stability between the production or storage zone and the ground surface or other intermediate layers.

This pipe string allows:

- to prevent the ingress of fluid from upper strata;
- to keep the hole from collapsing due to the pressure of the geological layers crossed;
- to isolate the inside part of the well from the surrounding soil;
- to continue drilling to the production or storage zone;
- to drive down the tubing string from the surface to the production or storage zone.

There may be two or more strings of casing, one inside the other, in a single well:

- surface casing: casing that extends from the surface to a depth sufficient to avoid any entering of surface waters or earth into the well;

- intermediate casing: casing set from the ground surface down to an intermediate depth. This intermediate depth is situated between the surface casing shoe and the production or storage zone;

- production casing: casing that extends through the surface casing and intermediate casing to the production or storage zone. The extremity of the production casing can be at the top or bottom of this zone.

3.2
cellar
excavation at ground surface, intended for housing the wellhead and safety shut-off devices.

EXAMPLE safety valves

3.3
cementation
process, and its result, which ensures the anchoring of well casing in the borehole and the tightness between different geological levels.

NOTE In the same time, this cementation can mitigate corrosion

3.4
centralizer
device constituted by a set of metallic blades which are fitted around the pipes of a string to keep them centred, either in the open hole (hole drilled in the ground), or inside pipes of larger diameter in which the considered string is installed. This device can also be used to ensure electrical continuity between the two concentric pipe strings

3.5
completion
process, and its result, which consists of fitting a well with the tubing to allow well operation in accordance with the applicable codes of practice and safety rules

3.6
flow-line
pipe connecting a well to a station

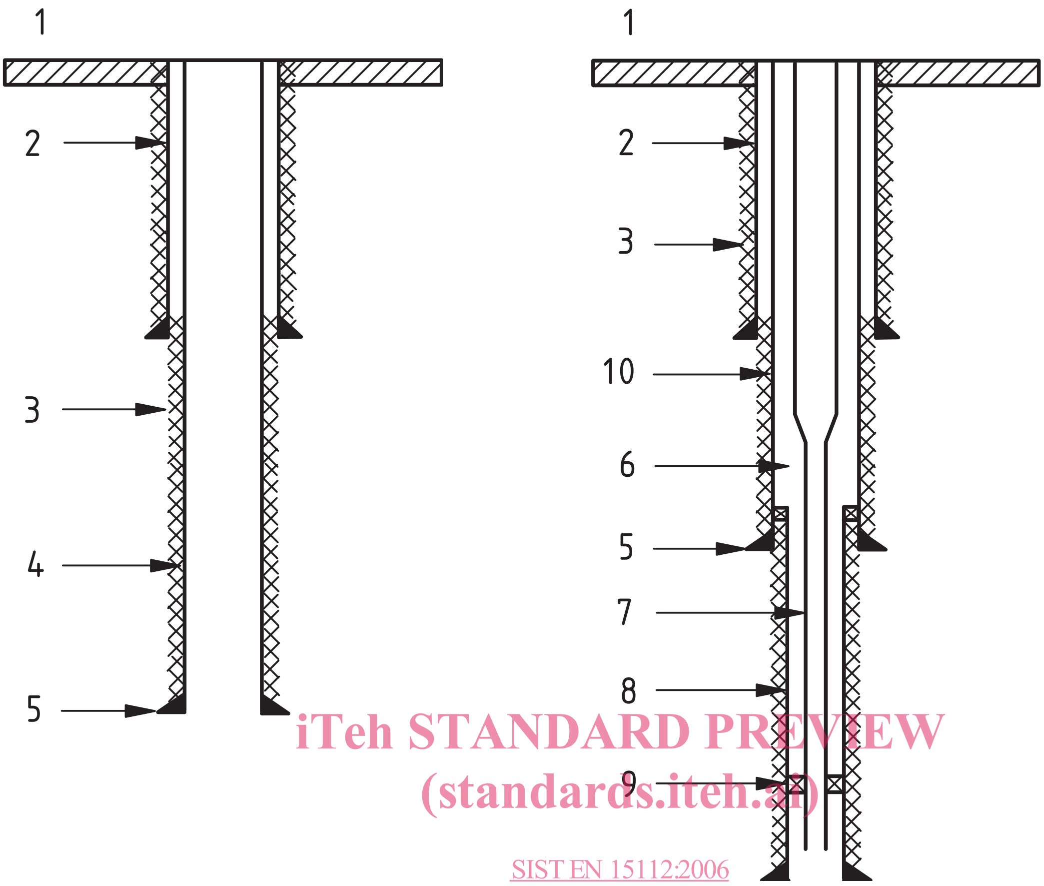
3.7
liner (bottom hole)
pipe having the same function as the casing but hung inside a casing (or another liner) and not at the wellhead like a conventional casing

3.8
packer (production)
device ensuring tightness of a pipe annulus. The production packer seals the annulus between the tubing and the production casing or liner

3.9
shoe
cylindrical element attached to the lower part of the casing, and allowing to place the casing in the borehole (guide shoe). If equipped with a valve, it makes easier the borehole cementation (cementing shoe)

3.10
tubing (production tubing)
pipe string, with its additional equipment, inside the production casing to allow the flow of oil, gas or water between the production or storage zone and the ground surface

3.11
wellhead
device installed at the top of the well, designed to hang the different pipe strings and to ensure tightness between the various annular spaces. The wellhead is fitted with valves to allow access (pressure monitoring, sampling) to the different annuli. Such fitted wellhead allows well operation and the intervention on the different components of the well. This device allows a good electrical continuity between all the pipe strings



Key

1 ground surface
2 surface casing
3 cementation
4 production casing
5 shoe
6 production annulus
7 tubing
8 liner (bottomhole)
9 packer (production)
10 intermediate casing

Figure 1 — Typical well completion equipment

4 Description and assessment of corrosion risks

4.1 General

Corrosion may occur on the external surface of well casings.

This corrosion, if not controlled, may lead to harmful damage such as losses of products, water, gas or oil, damage to the well and its completion (internal equipment), damage to the environment, for instance in allowing exchange between different geological formations. There is also the possibility of harm for people living near such installations.

The risks of corrosion should be considered in order to decide if cathodic protection shall be applied to the structure.

4.2 Description of corrosion risks

In general, for technical reasons, well casings should be covered by cement. In such conditions steel is passive, its potential is uniform under the cement and the corrosion hazards are reduced. In this case, cathodic protection should not be necessary.

In fact, due to the heterogeneity of the soils which are crossed during drilling and specifically due to the heterogeneity of the mechanical properties of these soils, it is not always possible to guarantee that a continuous cement layer covers the whole steel surface. Because of this non-homogeneous cement layer, some parts of the casing surface are in contact with the external medium. Macro-electrochemical cells (steel/cement and steel/medium) are then established and this results in a corrosion of the anodic parts of the cells (steel in the medium).

If there is no isolating joint between the well and surface piping, such detrimental macro-cells may also appear between the casing and the bare or poorly coated parts of the buried structure surface which become the anodic parts of the macro-cell.

Corrosion caused by the currents generated by macro-cells is more severe where soil layers with low resistivity are crossed.

Risks of corrosion damage shall be considered particularly where:

- the designed service life is long (depending on location, operational conditions);

- the procedure and execution of the cementation results in areas not or incorrectly cemented;

- there are stray current sources;

- the geological layers crossed are of a different nature.

4.3 Corrosion risk assessment

The previous information is only intended to provide a general idea on the corrosion risks involved.

Usually, a corrosion risk is assessed by measuring the structure-to-electrolyte potential. However, these potential measurements require installation of a reference electrode in the electrolyte in the immediate vicinity of the metal. For a well casing, access is limited to the upper part of the well and it is thus impossible to perform any measurement on the deep borehole.

During drilling, samples of drill cuttings should be checked and recorded at regular depths, particularly if their make up changes, to assess corrosivity and composition if the strata changes.

As an alternative to the above method, another way could be to carry out an accurate analysis of the electric log surveys which have been recorded in the open borehole.

Another approach consists in establishing whether current coming from the outside environment (ground) enters in or, conversely, exits from the casing, by using the method known as voltage drop profile (Annex A), which allows this determination by following the direction and intensity of currents circulating in the casing along the well.

This method allows localization of all areas where there is corrosion. Furthermore, according to the voltage drop observed, it is possible to assess the importance of the current intensity exiting from the casing, which determines the rate of corrosion. Nevertheless, this method is difficult to implement.

If available, the usual logs performed after borehole cementation can be usefully analysed to ascertain quality and homogeneity of the borehole cementation, especially in the areas with low electrical resistivity.

5 Prerequisites for application of cathodic protection

5.1 General

The requirements defined in EN 12954 shall be met. However, it should be taken into account that the well casing is bare and in contact with the soil in the borehole through the cement.

5.2 Electrical continuity

If a well is to be cathodically protected, a number of precautions shall be taken during completion. In addition to the external parts in contact with the borehole cementation or the soil, for which protection is required, the well generally includes other parts which are not in contact with the surrounding soil. The latter comprise the production string and all or part of intermediate and production casings depending on the type of completion, operation mode, the depth and the diameter.

It is necessary to avoid current flow through an electrolyte located in the annular space, since it could cause corrosion. Annular spaces which are not cemented are generally filled with a liquid which may be brine, mud water and so on. Under such conditions, current flow through the electrolyte shall be prevented by the use of bonds between each string.

Therefore it is necessary:

- to establish metallic bonds to ensure perfect electrical continuity of each casing part, at upper (wellhead) and lower (shoe) levels, and

- to install metallic centralisers where geological layers may promote a flow of current into the casing.

5.3 Electrical isolation

5.3.1 General

In principle, there should be no electrical continuity between the well to be protected and the foreign structures and particularly the flow-line. For this purpose, an isolating joint is installed between the well and its flow-line.

In this case, a special attention shall be given to avoid undesirable electrical shunts which may be caused by metallic bonds due to the small diameter pipes which are used for well control and safety devices.

Another problem may appear when the fluid or a part of the fluid conveyed in the flow-line is a low-resistivity electrolyte. An internal corrosion risk may exist due to a possible voltage drop between both sides of the isolating joint. In such a case, the isolating joint shall be internally coated with a suitable and electrically isolating material. Moreover, the internal coating shall be: