Protection of metallic materials against corrosion — Corrosion likelihood in soil —

Part 2: Low alloyed and non alloyed ferrous materials

The European Standard EN 12501-2:2003 has the status of a British Standard

ICS 77.060

British Standards

National foreword

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The UK participation in its preparation was entrusted to Technical Committee ISE/NFE/8, Corrosion of metals and alloys, which has the responsibility to:

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Contents

Foreword

This document (EN 12501-2:2003) has been prepared by Technical Committee CEN/TC 262 "Metallic and other inorganic coatings", 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of an identical text or by endorsement, at the latest by October 2003, and conflicting national standards shall be withdrawn at the latest by October 2003.

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Introduction

This European Standard should be used in conjunction with EN 12501-1, *Protection of metallic materials against corrosion — Corrosion likelihood in soil — Part 1: General,* which describes general principles of the assessment of the corrosion load.

The method of assessing the corrosion load in the case of a new structure to be installed takes into account the adverse parameters of the soil and environment with regard to corrosion. They have been chosen to avoid underestimation of the risks of corrosion damage. The assessment is performed considering a bare structure in direct contact with the soil without taking into account any protective system that will be present in service.

The complexity of corrosion in soil demands that the measurements and their interpretation are carried out by experienced personnel. The described method should be adapted in relation to the expected service life of the structure and to possible future changes of its environment.

1 Scope

This part of this European Standard deals with the assessment of the corrosion load in soil for low-alloyed and non-alloyed ferrous materials in direct contact with soil. Corrosion protection systems and their performance are not covered by this standard but by specific products standards.

This part of this European Standard deals with the case of new structures to be buried and gives information for existing structures.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text, and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN 12501-1:2003, *Protection of metallic materials against corrosion — Corrosion likelihood in soil — Part 1: General.*

3 Terms and definitions

For the purposes of this European Standard, the terms and definitions given in EN 12501-1:2003 apply.

4 Assessment of the corrosion load in soil for a new structure to be buried

4.1 Method

The method to be applied is based on:

— general concepts and factors influencing the corrosion load given in EN 12501-1;

— criteria defined in the present standard.

The corrosion load is accepted high if no investigation is done for any reason.

4.2 Criteria

4.2.1 Soil conditions

Table 1 summarises different soil conditions to be examined during either the preliminary inquiry or the site survey and which indicate a location of high corrosion load, in the absence of further investigation.

Table 1 — soil conditions that can lead to a high corrosion load

Characteristics	Circumstances	Examples of criteria
Type of soil	Natural soil	Presence of peat, lignite, coal .. in the soils Areas such as marsh, fen, .. Tidal zone Presence of brackish or sea water table Anaerobic soils (Possible Microbially Induced Corrosion)
	Artificial soil	Soils containing ashes, slag, industrial by-products, residues of household refuse, ... Areas backfilled by industrial by-products (any type) Uncontrolled recycled materials
Electrical influence	Device using DC	Close vicinity of DC railways, tramways, underground, ... Proximity of a cathodically protected structure, or anodes, ...
	Device using AC	Proximity of AC power lines, AC railways Proximity to AC earthing electrodes
Pollution	Contaminated soils	Contamination by de-icing salts, manure, fertilisers, leaking sewer, industrial pollution
Others	Topography Hydrography	Presence on the pipe route of a low point, a creek or river crossing, ...
	Toponomy	Indications from the village names of special characters of the nature of soil
	Three phase boundary	Fluctuating water table

4.2.2 Preliminary Inquiry

A preliminary inquiry generally consists of a topographical study, a geological study and an investigation for specific information. It enables to identify areas which should be studied with particular attention during the site survey.

Annex B gives more detailed information on the way to collect data during the preliminary inquiry.

In the absence of further investigation, such as site survey or soil sampling, and if one or more criteria as given in table 1 are met corrosion load is accepted high.

4.2.3 Site survey

A site survey consists in collecting additional information (see Table 1) by observations and measurements on the construction site; soil resistivity measurements have to be performed and, when appropriate, potential gradient measurements.

Annex B gives additional information on the way to carry out a site survey.

The following criteria allow to assess the corrosion load, based on visual inspection of soil and resistivity measurements from the surface during the site survey:

— resistivity values below 30 Ω·m and/or soil conditions as given in Table 1 indicate locations of high corrosion load;

— if resistivity values are above 30 Ω·m, additional investigation such as soil sampling shall be done. However, if the three following conditions are fulfilled together, they indicate locations of low corrrosion load and no other investigation is necessary:

  — soil is sand or gravel,

  — resistivity values are above 100 Ω·m, for site survey conditions representative of the average soil moisture content and temperature values,

  — soil conditions as given in Table 1 are absent.

In addition, in case of a possible electrical influence, whatever its origin, measurements should be taken on site in order to assess more precisely its effects on the estimation of the corrosion load. If no measurement is performed the corrosion load is accepted high.

4.2.4 Soil sampling

Soil samples are taken at various locations on site taking into account the nature, the heterogeneity and the wetness of the soil; the resistivity and pH values of the soil samples are then measured in the laboratory.

Annex B gives additional information on the procedure and measurement methods used for soil sampling.

The minimum resistivity value ρ^* and the pH value measured on a soil sample after addition of deionized water allow to assess the corrosion load using Table 2; the evaluation of soils on the border between two fields of corrosion load requires expert knowledge.

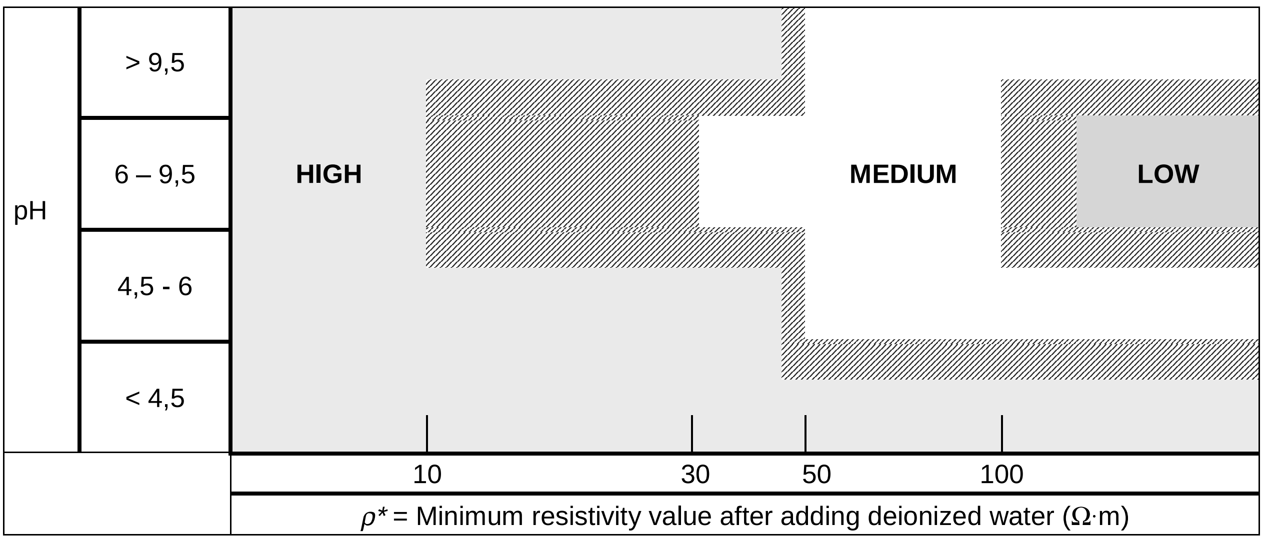
In addition, a medium corrosion load should be changed to high when heterogeneous soil conditions occur at the level of the structure, such as:

— presence of a water table (partly submerged structure);

— wide range of ρ^* values of samples (ρ^*max / ρ^*min > 3);

— wide range of pH values of samples (pHmax - pHmin > 1,5).

Table 2 — Corrosion load (free corrosion without concentration cell)



4.2.5 Backfill materials

The corrosion of a buried structure will depend upon the corrosion load of the native soil, but also upon the backfilling procedure, the backfill materials (especially if they are different from the native soil) and the possible leaching conditions. An assessment of the corrosion load of imported backfill materials should therefore be carried out as it may either increase or reduce the effective corrosion load on the structure.

Table 3 indicates criteria to be met by the backfill materials in order to lead to a low corrosion load.

Table 3 — Criteria for backfill materials

Parameters	Low corrosion load
Resistivity	$\rho^* > 100\ \Omega\cdot m$
pH[a]	6 < pH < 9
Sulfide	< 10 mg/kg
Carbon	No visual detection of coal, coke, graphite, carboniferous residues

[a] Materials outside this pH range, but with low acidity or alkalinity amount, could be considered as leading to a low corrosion load.

When industrial by-products are considered as backfill materials, the presence and amount of metallic salts should also be considered in order to avoid possible galvanic corrosion.

The use of selected backfill materials as shown in Table 3 can reduce the corrosion load (from high to medium or from medium to low), but only when the following conditions are fulfilled:

— no water table or leaching conditions that could cause contamination from the surrounding native soil;

— no mixed soils (native and imported) in contact with the structure.

5 Complementary information for an existing structure

5.1 General

In the case of an existing structure, the corrosion load in soil is assessed either to perform a diagnosis in order to evaluate the remaining life time of the structure or to establish the reasons of corrosion damages and/or failures on the structure.

As the structure actually lays in the soil, more information can be collected than in the case of a new structure (see EN 12501-1:2003; annex B). This covers:

— the information on the structure itself (such as corrosion effects, operating conditions);

— the characteristics of the soil directly in contact with the walls of the structure;

— the effect of the environment (mainly electrical influences);

— the system of protection (type of coating, cathodic protection, ...).

The three steps of the procedure for a new structure can be used for the assessment of the corrosion load; but the investigation conducted during preliminary inquiry, site survey and soil sampling will be more complete than for a new structure. Moreover, it is also possible to take into account samples coming from the structure itself to perform the assessment.

Depending on the economical impact, the assessment of the corrosion load in soil will include more or less extensive field measurements and/or laboratory analyses. The more accurate the assessment of the corrosion load is required, the more detailed will be the characterisation and the more expert knowledge will be necessary.

5.2 Investigations and analysis

During site survey, electrical measurements such as electrochemical potential of the structure, voltage gradient in soil in the vicinity of the structure will provide information about the electrical influences from surrounding devices on the structure. Information about the water table will be taken into account.

It is possible to take soil samples close to the structure. Chemical data, such as chloride, sulfate, sulfide contents, alkalinity or acidity amount, will generally supplement resistivity and pH values used in the case of a new structure. Soil nature identification and other analyses, such as soil grains size distribution, relative to anaerobic conditions will be performed to identify the corrosion process taking place in the soil.

In the case of an excavation exposing the structure, it is possible to take soil samples in direct contact with the surface of the structure and, if present, associated corrosion products.

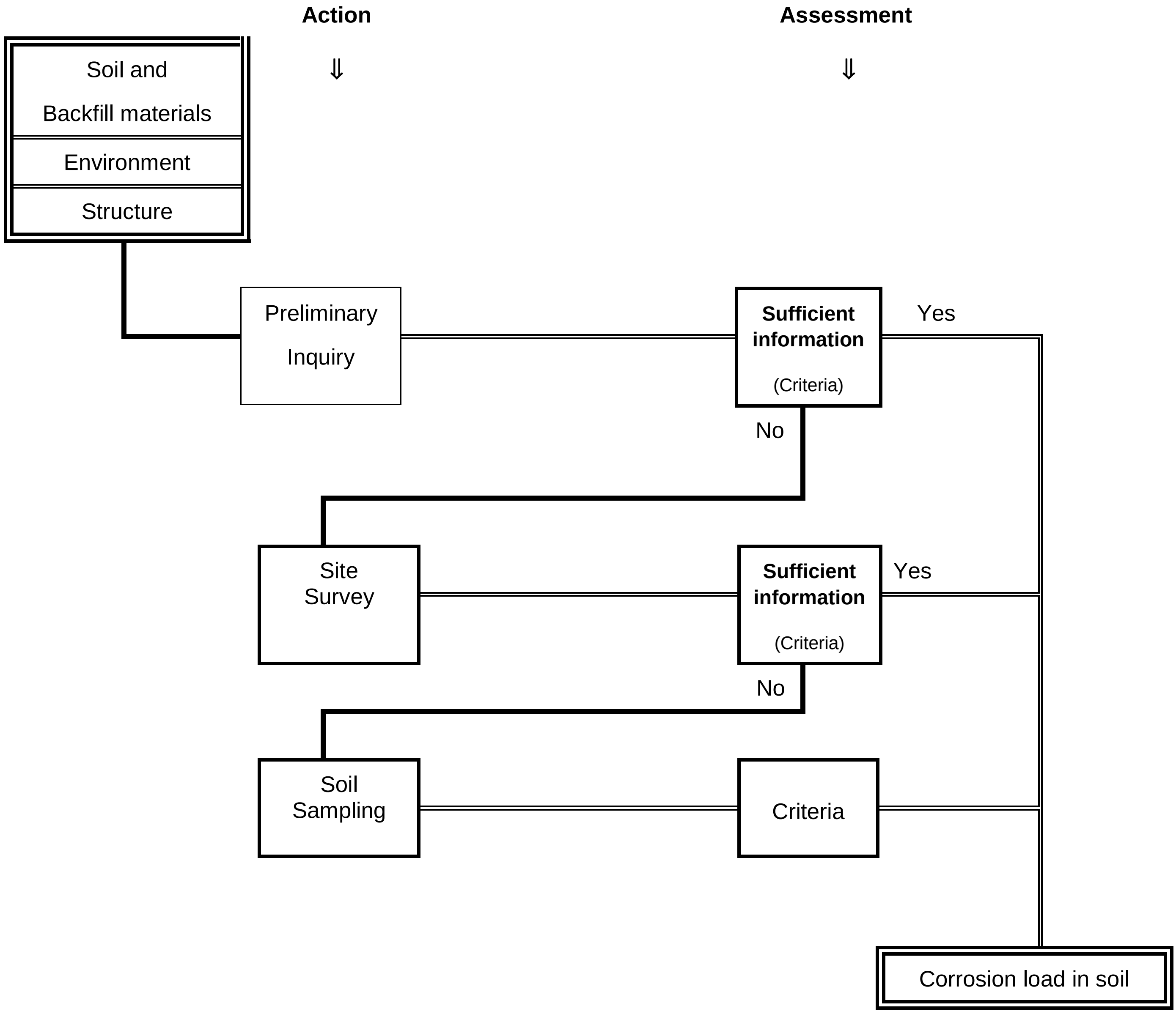
The visual examination of the surface of the structure can give information on the type of corrosion effects and damages and on the corrosion process involved.

If necessary, a sample of the structure can be taken together with a sample of soil in contact; this will allow a quantification of the corrosion damages with direct relationship with the soil characteristics and will lead to a better knowledge of the corrosion load and a better forecast of the remaining life time of the structure.

The analysis to be performed on these samples (soil, corrosion products, structure) requires suitable handling and conditioning, and sophisticated equipment only available in specialised laboratories. The high costs of the analysis make it necessary that the investigations to be performed are selected by experienced personnel well aware of all the particulars of the specific case. Therefore it is not possible to establish a single procedure for assessing the corrosion load in soil when investigating an existing structure.

Annex A
(informative)

Procedure for assessing the corrosion load in soil in the case of a new structure



After each step, the decision whether to stop or to continue the investigation can be taken. The possible lack of information is counterbalanced by accepting a higher corrosion load.

Annex B
(informative)

General principles of soil studies

B.1 Preliminary inquiry

B.1.1 General

The preliminary inquiry generally consists of a topographical study, a geological study and an investigation for specific information.

B.1.2 Topographical study

The topographical study involves the examination of ordnance survey maps and other types of maps; it provides information such as:

— ground contours;

— wet areas;

— ponds, swamps, lakes, peat bogs, etc..;

— estuaries, polders, marshes, saline soils bordering the sea;

— water course to be crossed in case of a long line structure.

B.1.3 Geological study

A geological study is carried out using geological maps and provides information on:

— the nature and characteristics of the soils;

— the hydrogeology, i.e. the presence of water table.

B.1.4 Investigation for specific information

This involves the collection of data from the local and regional authorities and utilities that can supplement existing information with respect to pollution indicators, such as:

— areas polluted by various effluents of industrial or other origins;

— deposits and tips of industrial origin;

— the proximity of other structures (sewers, industrial pipelines, etc.) which could cause pollution;

— industries and transport systems using direct or alternating electric current.

B.2 Site Survey

B.2.1 General

The site survey consists in collecting additional information to be obtained by observations and measurements.

Special attention should be given to the most unfavourable conditions, such as locations and periods when measurements are taken.

B.2.2 Resistivity measurement

Resistivity determination by the four pin method, depending on the distance between the pins inserted into the ground, gives approximately the overall soil resistivity at a depth equal to pin spacing.

These measurements from the surface can provide a vertical resistivity profile and an horizontal resistivity profile of the different soils or layers crossed by the structure. For a given location, it is advisable to carry out the measurements with two spacings or more, depending on the vertical dimension of the structure.

Other measurement methods may also be used: inserting a Columbia probe, three pin method, etc...

Resistivity values measured from the surface can help to choose the locations for soil sampling.

B.2.3 Measurement of potential gradients in soil

The presence of potential gradients in soil can be checked during the site survey and their intensity measured when possible electrical influences have been detected during the preliminary inquiry.

B.3 Soil sampling

B.3.1 General

Soil samples should be taken in such a way that they will be representative for the soil surrounding the structure. The samples should be kept in an airtight bag (e.g. plastic sack) and analyzed as soon as possible in order to avoid any physical or chemical changes in the sample.

B.3.2 Minimum resistivity value after adding deionized water

Among parameters used to characterise a soil, resistivity is the one providing the most information. The soil resistivity depends on the nature and amounts of dissolved salts, particularly chlorides and sulfates, and therefore on the amount of water present.

The minimum resistivity value (ρ^*) is extrapolated from the evolution of the resistivity of a soil mixture after adding repeatedly known volumes of deionized water to a sample of soil (sieve size < 5 mm). The sample is compressed into a soil box (by example with two plates electrodes). The measured resistance value is converted to soil resistivity depending on the geometry of the box.

B.3.3 pH value

In the majority of cases, the pH levels of natural soils are comprised between 6 and 9. Soils with a pH below 6 are only encountered in the natural state in peat or in siliceous soils corresponding with primary geological levels.

Very acid or very alkaline pH levels generally indicate pollution of an industrial origin. However in certain geological formations, very low pH values may be encountered in soils with originally high sulphide content and where the sulphide has oxidised to sulphate.

The pH measurement is performed on a soil mixture obtained by adding generally two parts of deionized water to one part of soil, and using a pH-meter.

B.3.4 Water table

The presence of a constant or fluctuating (seasonal effect) water table has an effect on the corrosion process.

The topographical, geological and environment data usually enable its existence to be predicted.

During taking the soil samples, a check can be made on the intrusion of any water into the boreholes as a function of the depth.

B.3.5 Heterogeneity

Heterogeneity leads to the formation of concentration cells. This can be assessed either by examination of the soil samples, or by profile or depth related resistivity determination, respectively for horizontal and vertical heterogeneity (the four pin method is well adapted to perform this evaluation directly on site; see B.2.1).

B.3.6 Type of soil

The nature of a soil and its texture provide information on the type of corrosion likely to occur. As an example, Table B.1 gives information on some types of soil.

Table B.1 — Types of soil

Type of soil	Resistivity range (Ωm)	Aeration
Marine mud	3 - 8	Very low
Clays and silts	5 - 20	Low to very low
Dry non-marine sands	200 - 2000	High

B.3.7 Microbial activity

With anaerobic conditions surrounding a buried structure, Microbially Induced Corrosion (MIC) may be encountered.

When MIC is suspected, special care should be taken during sampling in order to enable an appropriate search for bacteria in accordance with specific procedures.

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