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Corrosion of metals and alloys — Vocabulary

Corrosion des métaux et alliages — Vocabulaire

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Foreword

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This document was prepared by Technical Committee ISO/TC 156, *Corrosion of metals and alloys*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 262, *Metallic and other inorganic coatings, including for corrosion protection and corrosion testing of metals and alloys*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This fifth edition cancels and replaces the fourth edition (ISO 8044:2015), which has been technically revised to include additional terms and definitions.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The definitions in this document have been drawn up with the objective of achieving a proper balance between precision and simplicity. The main objective of this document is to provide definitions that can be understood to have the same meaning by all concerned. Some corrosion terms in present use have developed through common usage and are not always logical. It has not, therefore, been possible to define certain terms in the form they are used in some countries. Because of the occasional conflicts between tradition and logic, some definitions inevitably represent a compromise.

An example of this kind of conflict is the term "corrosion". This has been used to mean the process, results of the process and damage caused by the process. In this document, corrosion is understood to mean the process. Any detectable result of corrosion in any part of a corrosion system is termed "corrosion effect". The term "corrosion damage" covers any impairment of the function of the technical system of which the metal and the environment form a part. Consequently, the term "corrosion protection" implies that the important thing is to avoid corrosion damage rather than to prevent corrosion, which in many cases is impossible and sometimes not necessary.

Corrosion of metals and alloys — Vocabulary

1 Scope

This document defines terms relating to corrosion that are widely used in modern science and technology. In addition, some definitions are supplemented with short explanations.

NOTE 1 Throughout the document, IUPAC rules for electrode potential signs are applied. The term “metal” is also used to include alloys and other metallic materials.

NOTE 2 Terms and definitions related to the inorganic surface treatment of metals are given in ISO 2080.

2 Normative references

There are no normative references in this document.

3 Terms related to corrosion in general

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
corrosion
physicochemical interaction between a metallic material and its environment that results in changes in the properties of the metal, and that may lead to significant impairment of the function of the metal, the environment or the technical system, of which these form a part

Note 1 to entry: This interaction is often of an electrochemical nature.

3.2
corrosive agent
substance that will initiate or promote *corrosion* (3.1) when in contact with a given metal

3.3
corrosive environment
environment that contains one or more *corrosive agents* (3.2)

3.4
corrosion system
system consisting of one or more metals and those parts of the environment that influence *corrosion* (3.1)

Note 1 to entry: Parts of the environment may be, for example, coatings, surface layers or additional *electrodes* (7.1.2).

3.5
corrosion effect
change in any part of the *corrosion system* (3.4) caused by *corrosion* (3.1)

3.6
corrosion damage
corrosion effect (3.5) that causes impairment of the function of the metal, the environment or the technical system, of which these form a part

3.7
corrosion failure
corrosion damage (3.6) characterized by the total loss of function of the technical system

3.8
corrosion product
substance formed as a result of *corrosion* (3.1)

3.9
scale
solid layer of *corrosion products* (3.8) formed on a metal at high temperature

Note 1 to entry: The term “scale” is also used in some countries for deposits from supersaturated water.

3.10
rust
visible *corrosion products* (3.8) consisting mainly of hydrated iron oxides

3.11
corrosion depth
distance between a point on the surface of a metal affected by *corrosion* (3.1) and the original surface of the metal

3.12
corrosion rate
corrosion effect (3.5) on a metal per unit time

Note 1 to entry: The unit used to express the corrosion rate depends on the technical system and on the type of corrosion effect. Thus, corrosion rate is typically expressed as an increase in *corrosion depth* (3.11) per unit time, or the mass of metal turned into *corrosion products* (3.8) per area of surface and per unit time, etc. The corrosion effect may vary with time and may not be the same at all points of the corroding surface. Therefore, reports of corrosion rates are typically accompanied by information on the type, time dependency and location of the corrosion effect.

3.13
corrosion resistance
ability of a metal to maintain *serviceability* (3.16) in a given *corrosion system* (3.4)

3.14
corrosivity
ability of an environment to cause *corrosion* (3.1) of a metal in a given *corrosion system* (3.4)

3.15
corrosion likelihood
qualitative and/or quantitative expression of the expected *corrosion effects* (3.5) in a defined *corrosion system* (3.4)

3.16
serviceability
<corrosion> ability of a *corrosion system* (3.4) to perform its specified functions without impairment due to *corrosion* (3.1)

3.17
durability
<corrosion> ability of a *corrosion system* (3.4) to maintain *serviceability* (3.16) over a specified time when the specified requirements for use and maintenance have been fulfilled

3.18
service life
<corrosion> time during which a *corrosion system* (3.4) meets the requirements for *serviceability* (3.16)

3.19
critical humidity
value of the relative humidity of an atmosphere above which there is a sharp increase in the *corrosion rate* (3.12) of a given metal

3.20
corrosion attack
corrosion effect (3.5) that is detrimental but has not progressed to the point of impairment of the function of the metal, the environment or the technical system, of which these form a part

3.21
pickling
removal of oxides or other compounds from a metal surface by chemical or electrochemical action

3.22
pitting resistance equivalent number
PREN
indication of the resistance of stainless steels and nickel-based alloys to pitting in the presence of chloride-containing water

Note 1 to entry: An example formula for PREN is given by

$$PREN = \%\,Cr + 3{,}3\,[(\%\,Mo) + 0{,}5\,(\%\,W)] + 16\,(\%\,N)$$

Note 2 to entry: In general, the higher the PREN the higher the resistance to *pitting corrosion* (4.15).

3.23
trap
micro structural site at which the residence time for a hydrogen atom is long compared to the residence time in an interstitial lattice site

3.24
time of wetness
period when a metallic surface is covered by adsorptive and/or liquid films of *electrolyte* (7.1.1) to be capable of causing *atmospheric corrosion* (4.4)

3.25
threshold stress
<stress corrosion cracking> tensile stress above which stress corrosion cracks initiate and grow for specified test conditions

3.26
threshold stress intensity factor for stress corrosion cracking
K_{ISCC}
stress intensity factor above which stress corrosion crack propagation is sustained

Note 1 to entry: The threshold stress intensity factor is a concept of linear elastic fracture mechanics (LEFM) and is applicable when the plastic zone size is large compared with the microstructure, the crack is sufficiently long, and a high constraint to plastic deformation prevails, i.e. under plane strain predominant conditions. For growing stress corrosion cracks, LEFM is not necessarily applicable in all detail but is adopted as a pragmatic tool that is commonly used.

Note 2 to entry: Stress corrosion cracks may initiate at a surface or a surface defect and grow in the “small crack” regime at stress intensity factor levels below the apparent threshold stress intensity factor. Therefore, LEFM is not applicable in the “small crack” regime.

4 Terms related to types of corrosion

4.1
electrochemical corrosion
corrosion (3.1) involving at least one *anodic reaction* (7.1.9) and one *cathodic reaction* (7.1.6)

4.2
chemical corrosion
corrosion (3.1) not involving an electrochemical reaction

4.3
gaseous corrosion
corrosion (3.1) with dry gas as the *corrosive environment* (3.3) and without any liquid phase on the surface of the metal

4.4
atmospheric corrosion
corrosion (3.1) with the earth's atmosphere at ambient temperature as the *corrosive environment* (3.3)

4.5
marine corrosion
corrosion (3.1) with sea water as the main agent of the *corrosive environment* (3.3)

Note 1 to entry: This definition includes both immersed and splash zone conditions.

4.6
underground corrosion
corrosion (3.1) of buried metals, soil being the *corrosive environment* (3.3)

Note 1 to entry: The term soil includes not only the naturally occurring material but also any other material, such as ballast and backfill, used to cover a structure.

4.7
bacterial corrosion
microbiologically influenced corrosion (4.37) due to the action of bacteria

4.8
general corrosion
corrosion (3.1) proceeding over the whole surface of the metal exposed to the *corrosive environment* (3.3)

4.9
uniform corrosion
general corrosion (4.8) proceeding at almost the same rate over the whole surface

4.10
localized corrosion
corrosion (3.1) preferentially concentrated on discrete sites of the metal surface exposed to the *corrosive environment* (3.3)

Note 1 to entry: Localized corrosion can result in, for example, pits, cracks or grooves.

4.11
galvanic corrosion
corrosion (3.1) due to the action of a *corrosion cell* (7.1.13)

Note 1 to entry: The term has often been restricted to the action of bimetallic corrosion cells, i.e. to *bimetallic corrosion* (4.12).

4.12
bimetallic corrosion
DEPRECATED: contact corrosion
galvanic corrosion (4.11) where the *electrodes* (7.1.2) are formed by dissimilar metals

4.13
impressed current corrosion
electrochemical corrosion (4.1) due to the action of an external source of electric current

4.14
stray-current corrosion
impressed current corrosion (4.13) caused by current flowing through paths other than the intended circuits

4.15
pitting corrosion
localized corrosion (4.10) resulting in pits, i.e. cavities extending from the surface into the metal

4.16
crevice corrosion
localized corrosion (4.10) associated with, and taking place in or immediately around, a narrow aperture or clearance formed between the metal surface and another surface (metallic or non-metallic)

4.17
deposit corrosion
localized corrosion (4.10) associated with, and taking place under or immediately around, a deposit of *corrosion products* (3.8) or other substance

4.18
water-line corrosion
corrosion (3.1) along, and as a consequence of the presence of, a gas/liquid boundary

4.19
selective corrosion
dealloying
corrosion (3.1) of an alloy whereby the components react in proportions that differ from their proportions in the alloy

4.20
dezincification of brass
selective corrosion (4.19) of brass resulting in the preferential removal of zinc

4.21
graphitic corrosion
selective corrosion (4.19) of grey cast iron resulting in the partial removal of metallic constituents and leaving graphite

4.22
intergranular corrosion
corrosion (3.1) in or adjacent to the grain boundaries of a metal

4.23
weld corrosion
corrosion (3.1) associated with the presence of a welded joint and taking place in the weld or its vicinity

4.24
knife-line corrosion
corrosion (3.1) resulting in a narrow slit in or adjacent to the filler/parent boundary of a welded or brazed joint

4.25
erosion corrosion
process involving conjoint *corrosion* (3.1) and erosion

Note 1 to entry: Erosion corrosion can occur in, for example, pipes with high fluid flow velocity and pumps and pipe lines carrying fluid containing abrasive particles in suspension or entrained in a gas flow.

4.26
cavitation corrosion
process involving conjoint *corrosion* (3.1) and cavitation

Note 1 to entry: Cavitation corrosion can occur, for example, in rotary pumps and on ships' propellers.

4.27
fretting corrosion
process involving conjoint *corrosion* (3.1) and oscillatory slip between two vibrating surfaces in contact

Note 1 to entry: Fretting corrosion can occur, for example, at mechanical joints in vibrating structures.

4.28
wear corrosion
process involving conjoint *corrosion* (3.1) and friction between two sliding surfaces in contact

4.29
corrosion fatigue
process involving conjoint *corrosion* (3.1) and alternating straining of the metal, often leading to cracking

Note 1 to entry: Corrosion fatigue can occur when a metal is subjected to cyclic straining in a *corrosive environment* (3.3).

4.30
stress corrosion
process involving conjoint *corrosion* (3.1) and straining of the metal due to applied or residual stress

4.31
stress corrosion cracking
cracking due to *stress corrosion* (4.30)

4.32
hydrogen embrittlement
process resulting in a decrease of the toughness or ductility of a metal due to absorption of hydrogen

Note 1 to entry: Hydrogen embrittlement often accompanies hydrogen formation, for example, by *corrosion* (3.1) or electrolysis, and can lead to cracking.

4.33
blistering
process resulting in a dome-shaped defect visible on the surface of an object and arising from localized loss of cohesion below the surface

Note 1 to entry: For example, blistering can occur on coated metal due to loss of adhesion between coating and substrate, caused by accumulation of products from *localized corrosion* (4.10). On uncoated metal, blistering can occur due to excessive internal hydrogen pressure.

4.34
spalling
fragmentation and detachment of portions of the surface layer or *scale* (3.9)

4.35
tarnishing
dulling, staining or discoloration of a metal surface, due to the formation of a thin layer of *corrosion products* (3.8)

4.36
aqueous corrosion
corrosion (3.1) with water or a water-based solution as the *corrosive environment* (3.3)

4.37
microbiologically influenced corrosion
MIC
corrosion (3.1) influenced by the action of microorganisms

Note 1 to entry: Compare with *bacterial corrosion* (4.7).

4.38
environmentally assisted cracking
cracking of a susceptible metal or alloy due to the conjoint action of an environment and mechanical stress

4.39
hydrogen-induced cracking
HIC
planar cracking that occurs in metals due to induced stresses when atomic hydrogen diffuses into the metal and then combines to form molecular hydrogen at *trap* (3.23) sites

4.40
hydrogen stress cracking
HSC
cracking that results from the presence of hydrogen in a metal and tensile stress (residual or applied or both)

Note 1 to entry: HSC describes cracking in metals that are not sensitive to *sulfide stress corrosion cracking (SSCC)* (4.43) but which may be embrittled by hydrogen when galvanically coupled, as the *cathode* (7.1.3), to another metal that is corroding actively as an *anode* (7.1.4). The term "galvanically induced HSC" has been used for this mechanism of cracking.

4.41
irradiation-assisted stress corrosion cracking
intergranular cracking of austenitic stainless steels resulting from a reduction in the chromium concentration in a very narrow band at the grain boundaries following exposure to high neutron irradiation doses exceeding one displacement per atom, which causes the migration of point defects to the grain boundaries

4.42
stepwise cracking
SWC
cracking that connects *hydrogen-induced cracking (HIC)* (4.39) on adjacent planes in a metal

Note 1 to entry: This term describes the crack appearance. The linking of hydrogen-induced cracks to produce stepwise cracking is dependent upon local strain between the cracks and embrittlement of the surrounding steel by dissolved hydrogen. HIC/SWC is usually associated with low-strength plate steels used in the production of pipes and vessels.

4.43
sulfide stress corrosion cracking
SSCC
cracking of metal involving *corrosion* (3.1) and tensile stress, residual and/or applied, in the presence of water and hydrogen sulfide

Note 1 to entry: SSCC is a form of *hydrogen stress cracking (HSC)* (4.40) and involves the embrittlement of the metal by the atomic hydrogen that is produced by acid corrosion on the metal surface. Hydrogen uptake is promoted in the presence of sulfides. The atomic hydrogen can diffuse into the metal, reduce ductility and increase susceptibility to cracking. High strength metallic materials and hard weld zones are prone to SSCC.

4.44
stress-oriented hydrogen-induced cracking
SOHIC
staggered small cracks formed approximately perpendicular to the principal stress (residual or applied) resulting in a “ladder-like” crack array linking (sometimes small) pre-existing *HIC* (4.39) cracks

Note 1 to entry: The mode of cracking can be categorised as *sulfide stress corrosion cracking (SSCC)* (4.43) caused by a combination of external stress and the local strain around hydrogen-induced cracks. SOHIC is related to SSCC and HIC/*stepwise cracking* (*SWC)* (4.42). It has been observed in parent material of longitudinally welded pipe and in the heat-affected zone (HAZ) of welds in pressure vessels. SOHIC is a relatively uncommon phenomenon usually associated with low-strength ferritic pipe and pressure vessel steels.

Note 2 to entry: Compare with *hydrogen embrittlement* (4.32).

[SOURCE: ISO 15156-1:2015, 3.22, modified — In Note 1 to entry, “SSC” has been replaced with “SSCC”. Note 2 to entry has been added.]

4.45
exfoliation corrosion
stratified form of subsurface *stress corrosion* (4.30) of susceptible primary wrought alloy mill products having a highly directional grain structure, accompanied by detachment of separate layers from the body of the material, formation of cracks and finally usually complete layer-by-layer disintegration of metal

Note 1 to entry: Exfoliation generally proceeds along grain boundaries, but with certain alloys and tempering it may develop along transgranular paths or a mixed intergranular/transgranular path.

Note 2 to entry: Layer corrosion can be developed on the first stage.

4.46
filiform corrosion
type of *corrosion* (3.1) proceeding under coating materials on metals in the form of threads, generally starting from bare edges or from local damage to the coating

Note 1 to entry: Usually the threads are irregular in length and direction of growth, but they may also be nearly parallel and of approximately equal length. It should be noted that filiform corrosion can occur under different *protective coatings* (5.5).

4.47
tribo-corrosion
any form of *corrosion* (3.1) that involves constant removal of the *passivation layer* (7.3.6) due to fluid or particle impact on the corroding surface or the friction between the corroding surface and another surface

Note 1 to entry: Tribo-corrosion includes but is not restricted to: *wear corrosion* (4.28), *fretting corrosion* (4.27) and *erosion corrosion* (4.25).

Note 2 to entry: This process may result in an increase in friction of bearing surfaces in addition to causing material loss.

4.48
impingement attack
form of *erosion corrosion* (4.25) in aqueous liquids under high velocity or turbulent flow conditions on the metal surface causing repetitive disruption of protective films leading to accelerated *localised corrosion* (4.10)

4.49
high temperature corrosion
corrosion (3.1) by gases or deposits or both gases and deposits occurring at elevated temperatures under conditions where aqueous *electrolytes* (7.1.1) no longer exist

Note 1 to entry: High temperature corrosion can become significant at temperatures above 170 °C depending on material and environment.

4.50
hot corrosion
corrosion (3.1) by gases or deposits or both gases and deposits forming a liquid phase during a *high temperature corrosion* (4.49) reaction

Note 1 to entry: Hot corrosion is a sub-term of high temperature corrosion.

Note 2 to entry: The most common liquid phases in which hot corrosion occurs are metal sulfates, metal vanadates and metal chlorides.

4.51
sulfidation
reaction of a metal or alloy with a sulfur-containing species to produce metal sulfides on or beneath the surface of the metal or alloy

4.52
metal dusting
carburization of metallic materials in process gases containing carbon oxides and hydrocarbons and with extremely low oxygen partial pressures leading to disintegration of the metal into dust of graphite, metal or carbides, or combinations

Note 1 to entry: The temperature range for metal dusting lies between 400 °C and 900 °C. For the mechanism to happen, a carbon activity higher than 1 in the process gas is required.

4.53
rebar corrosion
corrosion (3.1) of reinforcement bars in concrete

5 Terms related to corrosion protection

5.1
corrosion protection
modification of a *corrosion system* (3.4) so that *corrosion damage* (3.6) is reduced

5.2
degree of protection
(percentage) reduction in *corrosion damage* (3.6) achieved by *corrosion protection* (5.1)

Note 1 to entry: All types of *corrosion* (3.1) present have to be considered.

5.3
temporary protection
corrosion protection (5.1) intended to last for a limited time only

Note 1 to entry: Temporary protection is used, for example, during storage and transportation of metal products or during shut-down of equipment.

5.4
protective layer
layer of a substance on a metal surface that decreases the *corrosion rate* (3.12)

Note 1 to entry: Such layers may be applied or arise spontaneously, for example, by *corrosion* (3.1).

5.5
protective coating
layer(s) of material applied to a metal surface to provide *corrosion protection* (5.1)

5.6
corrosion inhibitor
chemical substance that, when present in the *corrosion system* (3.4) at a suitable concentration, decreases the *corrosion rate* (3.12) without significantly changing the concentration of any *corrosive agent* (3.2)

Note 1 to entry: A corrosion inhibitor is generally effective in a small concentration.

5.7
volatile corrosion inhibitor
VCI
corrosion inhibitor (5.6) that can reach the metal surface in the form of vapour

5.8
de-aeration
removal of air from the environment

Note 1 to entry: If only oxygen is removed, the term "de-oxygenation" is more appropriate.

5.9
protective atmosphere
artificial atmosphere, of which the *corrosivity* (3.14) has been reduced by the removal or exclusion of *corrosive agents* (3.2) or by the addition of *corrosion inhibitors* (5.6)

5.10
critical potential
DEPRECATED: threshold potential
electrode potential (7.1.18) above or below which the *corrosion current* (7.2.3) varies markedly

Note 1 to entry: A critical potential is not an accurate value but may represent a small potential range of about 0,1 V width.

5.11
earth resistance
ohmic resistance between an electrode in infinite space and a second, sufficiently remote electrode with infinite surface area, without consideration of *polarization resistance* (7.2.10)

Note 1 to entry: The earth resistance depends on the geometrical data of the first electrode and the resistivity of the medium within the space.

5.12
ground bed resistance
earth resistance (5.11) of a ground bed

Note 1 to entry: The ground bed is an *anode* (7.1.4) and its backfill at *cathodic protection* (7.4.3) in soil.

5.13
instant-off potential
<cathodic protection technique> *electrode potential* (7.1.18) that is measured immediately after switching off the *polarization* (7.1.28) current

5.14
on-potential
<cathodic protection technique> non-IR-free potential of the object to be protected, measured when the protection current is still flowing

6 Terms related to corrosion testing

6.1
corrosion test
test carried out to assess the *corrosion resistance* (3.13) of a metal, the environmental contamination by *corrosion products* (3.8), the effectiveness of *corrosion protection* (5.1) or the *corrosivity* (3.14) of an environment

6.2
field corrosion test
corrosion test (6.1) conducted in a natural environment, such as air, water or soil

6.3
service corrosion test
corrosion test (6.1) conducted in service

6.4
simulated corrosion test
corrosion test (6.1) conducted under simulated service conditions

6.5
accelerated corrosion test
corrosion test (6.1) carried out under more severe conditions that will yield results in a shorter time than in service

6.6
cyclic atmospheric corrosion test
accelerated corrosion test (6.5) by exposure of coated and uncoated specimens to alternating environmental conditions designed to compare performance in atmospheric exposure

6.7
salt spray test
accelerated corrosion test (6.5) in a test cabinet by spraying the test specimens or objects with a solution containing sodium chloride

Note 1 to entry: Three types of salt spray tests exist in ISO 9227. These are the following:

— neutral salt spray (NSS) test with (50 ± 5) g/l sodium chloride;

— acetic acid salt spray (AASS) test with the test solution for NSS test acidified with glacial acetic acid;

— copper-accelerated acetic acid salt spray (CASS) test with the test solution for AASS test completed with copper(II) chloride dihydrate ($CuCl_2$ $2H_2O$).

6.8
scab-test
outdoor *accelerated corrosion test* (6.5) by intermittent spraying test specimens or objects with a spray of sodium chloride solution

Note 1 to entry: The method is suitable for specimens and objects of metals with or without coating.

Note 2 to entry: The name “scab” is an acronym of simulated corrosion atmospheric breakdown.

6.9
slow strain rate test
test for evaluating the susceptibility of a metal to *stress corrosion cracking* (4.31), which most commonly involves pulling a tensile specimen to failure in a representative environment at a constant displacement rate chosen to generate nominal strain rates usually in the range 10^{-5} s^{-1} to 10^{-8} s^{-1}

Note 1 to entry: Slow strain rate testing may also be applied to other specimen geometries, e.g. bend specimens.

7 Terms related to electrochemical matters

7.1 The electrochemical cell

7.1.1
electrolyte
medium in which an electric current is transported by ions

7.1.2
electrode
electronic conductor in contact with an *electrolyte* (7.1.1)

Note 1 to entry: In the electrochemical sense, the electrode is in fact restricted to narrow regions on both sides of the interface of this system.

7.1.3
cathode
electrode (7.1.2) at which a *cathodic reaction* (7.1.6) predominates

7.1.4
anode
electrode (7.1.2) at which an *anodic reaction* (7.1.9) predominates

7.1.5
electrode reaction
transfer of charge between an electronic conductor and an *electrolyte* (7.1.1)

7.1.6
cathodic reaction
transfer of negative charge from the electronic conductor to the *electrolyte* (7.1.1)

Note 1 to entry: Current enters the electronic conductor from the electrolyte. A cathodic reaction is a *reduction* (7.1.7) process, e.g. ½ $O_2 + H_2O + 2e^- \rightarrow 2OH^-$.

7.1.7
reduction
process in which a reactant accepts one or more electrons

7.1.8
reducing agent
substance causing *reduction* (7.1.7) by donating electrons

Note 1 to entry: During reduction, the reducing agent is oxidized.

7.1.9
anodic reaction
electrode reaction (7.1.5) equivalent to a transfer of positive charge from the electronic conductor to the *electrolyte* (7.1.1)

Note 1 to entry: Current enters the electrolyte from the electronic conductor. An anodic reaction is an *oxidation* (7.1.10) process. An example common in *corrosion* (3.1) is: $M \rightarrow M^{n+} + ne^-$.

7.1.10
oxidation
process in which a reactant loses one or more electrons

7.1.11
oxidizing agent
substance causing *oxidation* (7.1.10) by accepting electrons

Note 1 to entry: During oxidation, the oxidizing agent is reduced.

7.1.12
galvanic cell
combination of different *electrodes* (7.1.2) connected in series with an *electrolyte* (7.1.1)

Note 1 to entry: The galvanic cell is an electrochemical source of electrical current and will produce a current when the electrodes are connected by an external electronic conductor.

7.1.13
corrosion cell
short-circuited *galvanic cell* (7.1.12) in a *corrosion system* (3.4) where the corroding metal forms one of its *electrodes* (7.1.2)

Note 1 to entry: With respect to the distance between *anodes* (7.1.4) and *cathodes* (7.1.3), one can distinguish: a) macrocells with dimensions from millimetres to several kilometres, and b) microcells of microscopic dimensions.

7.1.14
concentration cell
<corrosion> *corrosion cell* (7.1.13) in which the potential difference arises from a difference in the concentration of *corrosive agent(s)* (3.2) near its *electrodes* (7.1.2)

7.1.15
differential aeration cell
<corrosion> *corrosion cell* (7.1.13) in which the potential difference arises from a difference in the concentration of oxygen near its *electrodes* (7.1.2)

Note 1 to entry: In some cases, the differential aeration cell may result in an *active-passive cell* (7.1.17).

7.1.16
bimetallic cell
corrosion cell (7.1.13) where the two *electrodes* (7.1.2) are formed by dissimilar metals

7.1.17
active-passive cell
corrosion cell (7.1.13) with one part of a metal surface in an *active state* (7.3.10) acting as an *anode* (7.1.4), and another part of the surface in a *passive state* (7.3.3) acting as a *cathode* (7.1.3)

7.1.18
electrode potential
voltage measured in the external circuit between an *electrode* (7.1.2) and a *reference electrode* (7.1.19) in contact with the same *electrolyte* (7.1.1)

7.1.19
reference electrode
electrode (7.1.2) having a stable and reproducible potential that is used as a reference in the measurement of *electrode potentials* (7.1.18)

7.1.20
corrosion potential
electrode potential (7.1.18) of a metal in a given *corrosion system* (3.4)

Note 1 to entry: The term is used whether or not there is a net (external) electrical current flowing to or from the metal surface under consideration.

7.1.21
free corrosion potential
open-circuit potential
corrosion potential (7.1.20) in the absence of a net (external) electrical current flowing to or from the metal surface

Note 1 to entry: See Figure A.1.

7.1.22
galvanic series
list of metals ordered according to their *free corrosion potentials* (7.1.21) under specified conditions

Note 1 to entry: Other electronic conductors may also be included.

7.1.23
pitting initiation potential
lowest value of the *corrosion potential* (7.1.20) at which pit initiation is possible on a passive surface in a given *corrosive environment* (3.3)

7.1.24
activation polarization
change of the *electrode potential* (7.1.18) due to charge transfer

7.1.25
anodic polarization
change of the *electrode potential* (7.1.18) in the positive direction caused by current flow

Note 1 to entry: Compare with *electrode polarization* (7.2.9).

7.1.26
cathodic polarization
change of the *electrode potential* (7.1.18) in the negative direction caused by current flow

Note 1 to entry: Compare with *electrode polarization* (7.2.9).

7.1.27
concentration polarization
portion of the *electrode polarization* (7.2.9) of a cell that is produced by concentration changes resulting from the passage of current through the *electrolyte* (7.1.1)

Note 1 to entry: Compare with *concentration cell* (7.1.14).

7.1.28
polarization
difference between the *electrode potential* (7.1.18) and the *free corrosion potential* (7.1.21) of the *electrode* (7.1.2) in the environment under consideration, which can, for example, be caused by the flow of current from an external source

7.1.29
resistance polarization
polarization (7.1.28) due to ohmic resistance in the *corrosion systems* (3.4)

7.1.30
overvoltage
voltage difference between the measured *electrode potential* (7.1.18) and the *equilibrium potential* (7.1.33)

7.1.31
anode potential
electrode potential (7.1.18) of the *anode* (7.1.4) of a *corrosion cell* (7.1.13) or *electrochemical cell* (7.1.44)

7.1.32
cathode potential
electrode potential (7.1.18) of the *cathode* (7.1.3) of a *corrosion cell* (7.1.13) or *electrochemical cell* (7.1.44)

7.1.33
equilibrium potential
electrode potential (7.1.18) of an *electrode* (7.1.2) that is in thermodynamic equilibrium with its environment

7.1.34
rest potential
corrosion potential (7.1.20) after time transients have subsided and near-equilibrium has been achieved

7.1.35
reference potential
potential difference between a *reference electrode* (7.1.19) and the standard hydrogen *electrode* (7.1.2)

Note 1 to entry: The reference potential of the standard hydrogen electrode is zero by convention.

7.1.36
redox potential
potential of a reversible oxidation-reduction reaction in a given *electrolyte* (7.1.1) recorded on a standard hydrogen electrode scale

Note 1 to entry: $\mathrm{Ox} + ne^- \underset{\text{oxidation}}{\overset{\text{reduction}}{\rightleftarrows}} \mathrm{Red}$.

7.1.37
standard electrode potential
equilibrium potential (7.1.33) with all reactants at a unit activity ($a = 1$) and in the standard conditions ($T = 298$ K, $P = 0{,}101\ 3$ MPa)

7.1.38
stress corrosion cracking potential
potential below which *stress corrosion cracking* (4.31) does not take place

7.1.39
counter electrode
auxiliary electrode
electrode (7.1.2) commonly used in applied *polarization* (7.1.28) to balance the current passing to the *working electrode* (7.1.45)

Note 1 to entry: It is usually made from a non-corroding material.

7.1.40
half cell
theoretical single *oxidation* (7.1.10) or *reduction* (7.1.7) half reaction occurring on an *electrode* (7.1.2)

Note 1 to entry: Two half cells connected form an *electrochemical cell* (7.1.44).

7.1.41
mixed electrode
electrode (7.1.2) where diverse *electrode reactions* (7.1.5) take place

7.1.42
Tafel slope
slope of the straight-line portion of an electrochemical *current density/potential curve* (7.2.8) [plotted in terms of logarithm of the *current density* (7.2.6) versus potential] corresponding to an activation-controlled reaction

Note 1 to entry: This is commonly expressed as volts per decade.

7.1.43
Luggin probe
Haber-Luggin capillary
Luggin-Haber capillary
small tube or capillary filled with *electrolyte* (7.1.1), terminating close to the metal surface under study and used to minimize potential drop between the *reference electrode* (7.1.19) and the test *electrode* (7.1.2)

7.1.44
electrochemical cell
system composed of an *anode* (7.1.4), a *cathode* (7.1.3) and an *electrolyte* (7.1.1)

7.1.45
working electrode
test *electrode* (7.1.2) in an *electrochemical cell* (7.1.44), designed for electrochemical tests

7.2 Reaction rates

7.2.1
anodic partial current
sum of all the currents corresponding to *anodic reactions* (7.1.9) on an *electrode* (7.1.2)

Note 1 to entry: See Figure A.1.

7.2.2
cathodic partial current
sum of all the currents corresponding to electrochemical *cathodic reactions* (7.1.6) on the *electrode* (7.1.2)

Note 1 to entry: See Figure A.1.

7.2.3
corrosion current
anodic partial current (7.2.1) due to metal *oxidation* (7.1.10)

Note 1 to entry: The corrosion *current density* (7.2.6) is equivalent to the rate of *electrochemical corrosion* (4.1) according to Faraday's law.

7.2.4
free corrosion current
corrosion current (7.2.3) at the *free corrosion potential* (7.1.21)

Note 1 to entry: See Figure A.1.

7.2.5
net current
<electrode> sum of all the *anodic partial currents* (7.2.1) and *cathodic partial currents* (7.2.2) on an *electrode* (7.1.2)

Note 1 to entry: The net current is dependent on many parameters, such as the *electrode potential* (7.1.18). See Figure A.1.

7.2.6
current density
current per area of an *electrode* (7.1.2)

7.2.7
limiting current
maximum electric current allowed by the slowest non-electrochemical step of a given *electrode* (7.1.2) process

7.2.8
current density/potential curve
polarization curve
diagram relating *electrode potential* (7.1.18) to *current density* (7.2.6)

7.2.9
electrode polarization
change of *electrode potential* (7.1.18)

Note 1 to entry: Often the *free corrosion potential* (7.1.21) is used as a reference value. The change may be caused, for example, by the application of an external electrical current or by the addition of an *oxidizing agent* (7.1.11) or *reducing agent* (7.1.8).

7.2.10
polarization resistance
quotient of *electrode potential* (7.1.18) increment and the corresponding current increment

Note 1 to entry: Usually the polarization resistance is measured in the vicinity of the *free corrosion potential* (7.1.21) (linear polarization measurement). The polarization resistance measured in this way may be related to the *free corrosion current* (7.2.4).

7.2.11
diffusion layer
<electrode> *electrolyte* (7.1.1) layer at the *electrode* (7.1.2) surface with a different concentration of a given species than that in the bulk of the solution

Note 1 to entry: In this layer, diffusion is an important transport mode for species formed or consumed at the electrode.

7.2.12
cathodic control
limitation of the *corrosion rate* (3.12) by the rate of the *cathodic reaction* (7.1.6)

7.2.13
anodic control
limitation of the *corrosion rate* (3.12) by the rate of the *anodic reaction* (7.1.9)

7.2.14
resistance control
limitation of the *corrosion rate* (3.12) by the ohmic resistance within the *corrosion cell* (7.1.13)

7.2.15
diffusion control
limitation of the *corrosion rate* (3.12) by the diffusion rate of *corrosive agents* (3.2) to, or *corrosion products* (3.8) from, the metal surface

7.2.16
mixed control
limitation of a *corrosion rate* (3.12) by the simultaneous action of two or more controlling factors

7.2.17
cell current
current that flows between an *anode* (7.1.4) and a *cathode* (7.1.3)

7.2.18
exchange current density
current density (7.2.6) at a single *electrode* (7.1.2) corresponding to the rate of internal charge transfer exchange within *anodic reactions* (7.1.9) and *cathodic reactions* (7.1.6) at their *equilibrium potential* (7.1.33)

7.3 Passivation

7.3.1
passivation
decrease of *corrosion rate* (3.12) by a *passivation layer* (7.3.6)

Note 1 to entry: Incomplete passivation may lead to *localized corrosion* (4.10).

7.3.2
passivator
chemical agent causing *passivation* (7.3.1)

7.3.3
passive state
passivity
state of a metal resulting from its *passivation* (7.3.1)

Note 1 to entry: See Figure A.2.

7.3.4
passivation potential
corrosion potential (7.1.20) at which the *corrosion current* (7.2.3) has a peak value, above which there is a range of potentials, and where the metal is in a *passive state* (7.3.3)

Note 1 to entry: See Figure A.2.

7.3.5
passivation current
corrosion current (7.2.3) at the *passivation potential* (7.3.4)

Note 1 to entry: If the *corrosive environment* (3.3) contains an *oxidizing agent* (7.1.11) being reduced at the passivation potential, the *net current* (7.2.5) measured will be lower than the passivation current.

7.3.6
passivation layer
passive layer
thin, adherent, *protective layer* (5.4) formed on a metal surface through a reaction between the metal and its environment

7.3.7
depassivation
increase of *corrosion rate* (3.12) of a passive metal caused by general or local removal of its *passivation layer* (7.3.6)

7.3.8
re-activation
depassivation (7.3.7) caused by a decrease of the *electrode potential* (7.1.18)

7.3.9
depassivator
chemical agent causing *depassivation* (7.3.7)

7.3.10
active state
state of a corroding metal surface being below the *passivation potential* (7.3.4)

Note 1 to entry: See Figure A.2.

7.3.11
re-activation potential
corrosion potential (7.1.20) below which *re-activation* (7.3.8) takes place

Note 1 to entry: See Figure A.2.

7.3.12
transpassive state
state of a metal polarized to a potential value above the range of a *passive state* (7.3.3) characterized by a considerable increase of the *corrosion current* (7.2.3) and in the absence of *pitting corrosion* (4.15)

Note 1 to entry: See Figure A.2.

7.3.13
transpassivation potential
corrosion potential (7.1.20) above which the metal is in a *transpassive state* (7.3.12)

Note 1 to entry: See Figure A.2.

7.4 Electrochemical protection

7.4.1
electrochemical protection
corrosion protection (5.1) achieved by electrical control of the *corrosion potential* (7.1.20)

7.4.2
anodic protection
electrochemical protection (7.4.1) created by increasing the *electrode potential* (7.1.18) to a value within the potential range of the *passive state* (7.3.3)

7.4.3
cathodic protection
electrochemical protection (7.4.1) created by decreasing the *electrode potential* (7.1.18) to a level at which the *corrosion rate* (3.12) of the metal is significantly reduced

7.4.4
galvanic protection
electrochemical protection (7.4.1) in which the protection current is obtained from a *corrosion cell* (7.1.13) formed by connecting a *counter electrode* (7.1.39) to the metal to be protected

Note 1 to entry: Galvanic protection can be cathodic or anodic.

7.4.5
impressed current protection
electrochemical protection (7.4.1) in which the protection current is supplied by an external source of electric energy

Note 1 to entry: Impressed current protection can be cathodic or anodic.

7.4.6
electrical drainage protection
electrochemical protection (7.4.1) against *stray-current corrosion* (4.14) by draining the stray-current from the metallic object

Note 1 to entry: The drainage can be obtained, for example, by connecting the metal to be protected to the negative part of the stray-current source.

7.4.7
protection potential range
range of *corrosion potential* (7.1.20) values in which an acceptable *corrosion resistance* (3.13) is achieved for a particular purpose

7.4.8
protection potential
threshold value of the *corrosion potential* (7.1.20) that has to be reached to enter a *protection potential range* (7.4.7)

7.4.9
protection current density
current density (7.2.6) that is required to maintain the *corrosion potential* (7.1.20) in a *protection potential range* (7.4.7)

7.4.10
galvanic anode
sacrificial anode
metallic component used as an *anode* (7.1.4) for *galvanic protection* (7.4.4) and *cathodic protection* (7.4.3)

Note 1 to entry: The galvanic anode must have a lower *corrosion potential* (7.1.20) than the metal that is to be protected.

7.4.11
insoluble anode
DEPRECATED: dimensionally stable anode
anode (7.1.4) used for *cathodic protection* (7.4.3) by *impressed current protection* (7.4.5) where the anode is not significantly consumed

EXAMPLE Platinized titanium.

7.5 Electrochemical corrosion tests

7.5.1
potentiostatic test
electrochemical test in which the *electrode potential* (7.1.18) is constantly maintained

7.5.2
potentiodynamic test
DEPRECATED: potentiokinetic test
electrochemical test in which the *electrode potential* (7.1.18) is varied continuously at a pre-set rate

7.5.3
potentiostep test
electrochemical test in which the *electrode potential* (7.1.18) is varied step-wise with time in a pre-set manner

7.5.4
potentiostaircase test
DEPRECATED: quasi-potentiostatic test
potentiostep test (7.5.3) in which the time duration and potential increments or decrements are equal for each step

7.5.5
galvanostatic test
DEPRECATED: intensiostatic test
electrochemical test in which the *current density* (7.2.6) is maintained constant

7.5.6
galvanodynamic test
electrochemical test in which the *current density* (7.2.6) is varied continuously with time at a pre-set rate

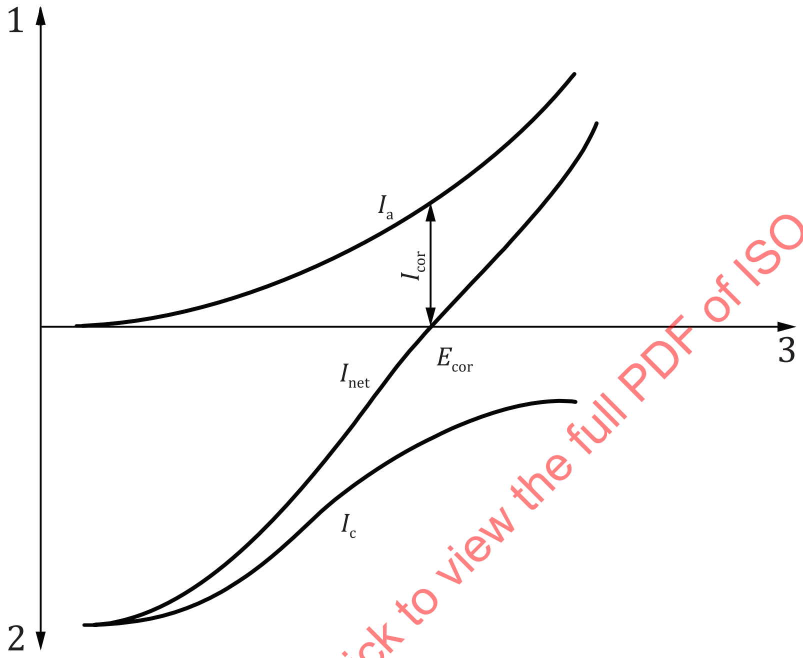
7.5.7
galvanostep test
electrochemical test in which the *current density* (7.2.6) is varied step-wise with time in a pre-set manner

7.5.8
galvanostaircase test
DEPRECATED: quasi-galvanostatic test
DEPRECATED: quasi-intensiostatic test
galvanostep test (7.5.7) in which the time duration and current increments or decrements are equal for each step

7.5.9
electrochemical impedance spectroscopy
EIS
electrochemical test based on the response of a corroding *electrode* (7.1.2) to small-amplitude alternating potential or current signals at various frequencies

Annex A
(informative)

Graphical representations of certain terms



Key

1 anodic current

2 cathodic current

3 electrode potential

E_{cor} free corrosion potential

I_a anodic partial current (in the absence of other anodic reactions, identical with the corrosion current)

I_c cathodic partial current

I_{net} net current

I_{cor} free corrosion current

Figure A.1 — Current/potential curves for a corroding electrode