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## ELECTROCHEMICAL CORROSION NOMENCLATURE

(Recommendations 1988)

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# Electrochemical corrosion nomenclature (Recommendations 1988)

Abstract - A general physicochemical definition of the term corrosion is given. The main part of the document treats electrochemical corrosion of metals and alloys including uniform corrosion in the active and passive states and various types of nonuniform corrosion.

The aim of this document is to provide scientific definitions in the field of corrosion. Because of their great practical importance, corrosion terms have already been defined for the purpose of technical standardization. The present document avoids disagreements with the earlier definitions if possible and concentrates on a more complete or rigorous description of the physicochemical basis of corrosion terms. As a consequence, terms of fundamental importance only will be discussed. Those of entirely technical importance are found e.g. in a recent document (ref. 1) of the International Standards Organization (ISO) which in part was worked out in collaboration with the IUPAC I.3 Commission on Electrochemistry. Technical definitions refer to corrosion of metals, but corrosion also affects other materials. This fact is taken into account in the general definition of corrosion given below. The major part of corrosion reactions are of an electrochemical nature. This document concentrates on electrochemical corrosion, i.e. corrosion due to charge transfer.

## 1. GENERAL TERMS

### 1.1 Corrosion

Corrosion is an irreversible interfacial reaction of a material (metal, ceramic, polymer) with its environment which results in consumption of the material or in dissolution into the material of a component of the environment.

Often, but not necessarily, corrosion results in effects detrimental to the usage of the material considered. Exclusively physical or mechanical processes such as melting or evaporation, abrasion or mechanical fracture are not included in the term corrosion.

### 1.2 Electrochemical corrosion

Electrochemical corrosion always involves electrode reactions (ref. 2). Typical examples are the corrosion of a metal by dissolution of metal ions or by formation of an oxide film.

### 1.3 Electrode reactions during electrochemical corrosion

There are at least two electrode reactions in electrochemical corrosion, one being anodic, the other one cathodic.

The electrode reactions proceed simultaneously on a uniform surface or on spatially separated areas. In the latter case an electric current flows between the anode and the cathode.

### 1.4 Corrosion potential ( $E_{\text{cor}}$ )

The corrosion potential is the electrode potential spontaneously acquired by a corroding material in a particular environment.

### 1.5 Corrosion rate ( $v_{\text{cor}}$ ), corrosion current ( $I_{\text{cor}}$ )

The corrosion rate is measured as the amount of substance transferred per unit time at a specified surface.

Using Faraday's law, the corrosion rate can be formally expressed as an electric current which at the corrosion potential is called the corrosion current. E.g. for the anodic dissolution of one component of a material with  $v_{\text{cor}}$  in  $\text{mol s}^{-1}$  and  $I_{\text{cor}}$  in A one obtains  $I_{\text{cor}} = nFv_{\text{cor}}$ ,  $n$  being the charge number of the electrode reaction and  $F$  the Faraday constant.

### 1.6 Polarization ( $\xi$ )

Polarization is the difference of the electrode potential from the corrosion potential.

It is measured like the overpotential as described in ref.3. The symbol  $\eta$  should not be used for polarization.

### 1.7 Uniform corrosion

Corrosion is uniform if the time average of the corrosion current through a unit area of any macroscopic dimension is independent of the position on the surface.

### 1.8 Nonuniform corrosion

Corrosion is nonuniform if the time average of the corrosion current through a unit area depends on its position on the surface.

Nonuniform corrosion can be due to inhomogeneities of structure or of composition of the corroding material, or to inhomogeneities of the environment. Special cases of nonuniform corrosion such as pitting or intergranular corrosion sometimes are called localized corrosion.

### 1.9 Selective corrosion

Selective corrosion is corrosion of a single phase having more than one component, when the ratio of the corrosion rates of the components differs from the ratio of bulk mole fractions.

Selective corrosion changes the composition of the material in the interfacial region.

## 2. UNIFORM CORROSION OF METALS AND ALLOYS

### 2.1 Corrosion in the active state

Corrosion in the active state occurs by direct transfer (which may involve one or several steps) of metal ions from the metallic phase to the adjacent electrolyte. A metal corroding in the active state is called an active metal.

The corrosion current of an active metal usually increases when the electrode potential is made more positive, other conditions remaining constant.

### 2.2 Corrosion in the passive state

The passive state is characterized by a contiguous "passivating film" of solid corrosion products separating the metallic phase from the adjacent electrolyte.

Corrosion in the passive state involves growth of the passivating film and/or transfer of metal ions through the film into the electrolyte.

A metal corroding in the passive state is called a passive metal.

### 2.3 Passivation potential

The passivation potential is the most negative electrode potential at which the passivating film is formed.

The passivation potential is equal to or more positive than the equilibrium potential of formation of the phase constituting the film. Usually, the corrosion current goes through a maximum at the passivation potential.

### 2.4 Passivation

Passivation is the process of transition from the active to the passive state by formation of the passivating film.

Passivation is achieved by an anodic current which at the respective electrode potential must be larger than the maximum current referred to in 2.3, or by the presence of an oxidized substance in the neighbouring solution which passivates by being reduced (passivator).

### 2.5 Activation

Activation is the process of transition from the passive to the active state by removal of the passivating film.

A necessary condition for activation is an electrode potential negative to the equilibrium potential of formation of the passivating film. Activation is achieved by cathodic currents, by a reduced substance in the adjacent solution, or by contact with an electronic conductor having a suitably negative corrosion potential.

#### 2.6 Component-currents of the passivating film

At the interface between the passivating film and the adjacent electrolyte the current consists of two or more component currents.

For example, anodic component currents are the transfer of metal ions from the passivating film into the electrolyte, and transfer of anions from the electrolyte into the film. The latter component current results in film thickening.

#### 2.7 Steady-state corrosion of a passive metal

The steady state is characterized by the current and the film thickness both being independent of time. In the steady state, the component current involving anions is zero and the corrosion current is equal to the component current involving metal ions.

The steady state anodic current depends on the composition of the film at the interface with the electrolyte, apart from other parameters such as electrolyte composition and temperature. The composition of the film changes with the electrode potential, in general. Therefore, the steady state corrosion current in the passive state may increase or decrease with the electrode potential.

### 3. NON-UNIFORM CORROSION

#### 3.1 Corrosion cell

A corrosion cell is a galvanic cell resulting from inhomogeneities in the material or in its environment (ref.3).

#### 3.2 Contact corrosion, galvanic corrosion

Contact corrosion is the enhancement of the corrosion rate of the material with the more negative corrosion potential in a corrosion cell resulting from the contact between different electron-conducting phases.

#### 3.3 Concentration-cell corrosion

Concentration-cell corrosion is the local variation of the corrosion rate due to the action of a corrosion cell resulting from inhomogeneous composition of the environment.

A common case of concentration-cell corrosion is that due to locally different concentrations of oxygen in the solution adjacent to the corroding material. Concentration-cells with locally different concentrations of oxygen are often called differential-aeration cells.

#### 3.4 Pitting corrosion

Pitting corrosion is a special type of nonuniform corrosion of passive metals resulting in the formation of pits.

Usually pitting corrosion occurs in the presence of certain anions at electrode potentials positive to a critical pitting potential.

### REFERENCES

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