CORROSION FEATURES OF STEEL STRUCTURES IN DIFFERENT ENVIRONMENTS

ATMOSPHERIC CORROSION

Atmospheric corrosion is the most common type of material destruction; about 80% of steel structures are operated at atmospheric conditions.

The main factor determining the mechanism and rate of atmospheric corrosion is the degree of wetting of the metal surface. Taking into account this factor, there are three main types of atmospheric corrosion:

1) Dry atmospheric corrosion – the destruction due to the presence of a very thin film of water absorption on the metal surface (at about a few molecular layers with the total thickness from 1 to 10 nm), which cannot yet be regarded as solid and having all electrolyte properties film.

2) Damp atmospheric corrosion - the destruction due to the presence of a thin invisible film of water on the metal surface which is formed as a result of the capillary, absorptive or chemical condensation at relative air humidity below 100% (the film thickness from 10 to 1000 nm).

3) Wet atmospheric corrosion - the destruction due to the presence of a visible water film on the metal surface (film thickness of 1 m to 1 mm). Corrosion of this type is observed at relative humidity of about 100% when there is a droplet of water condensation on metal surfaces, as well as direct contact with water on the surface (rain, hydrofining of surfaces, etc.).

It is obvious that the minimum rate of metal destruction takes place in the dry atmospheric corrosion, which occurs by chemical mechanism.

The increase of water film may lead to the transition from chemical corrosion mechanism to electrochemical one that corresponds to a rapid increase of the corrosion process rate.

In practice, it is hard to distinguish these three types of atmospheric corrosion, since, they may change from one type to another depends on the external conditions. For example, the metal structure, which has metal fracture due to dry corrosion mechanism, with the increasing of air humidity starts to corrode due to wet corrosion mechanism. In case of precipitation wet corrosion takes place already. During the drying process it will vary in the opposite direction.

The rate of atmospheric corrosion of metals is influenced by several factors. The main of them should be considered as the length of wetting the surface, which is mainly determined by the value of relative humidity. In most practical cases, the corrosion rate of the metal sharply increases only upon reaching a certain critical value of the relative humidity. In this case, a continuous film of moisture appears on the metal surface as a result of condensation of water from the air.

The air impurities (SO2, H2S, NH3, HCl, etc.) strongly effect on the rate of atmospheric corrosion. Dissolved in the water film, it increases its electrical conductivity and hygroscopicity of the corrosion products.

Particulate matter from the air, falling onto the surface of a metal can act as contaminants (NaCl, Na2SO4), or in the form of solid particles may facilitate condensation of moisture on the surface (coal particles, dust, abrasive particles, etc.).

CORROSION IN SEAWATER

Sea water is a well-aerated electrolyte with high conductivity and a neutral pH, the presence of salts from 2 (water bays, the sea at the confluence of the rivers) to 40%. The average salinity of the open seas and oceans is 35%. Saline seawater composition consists essentially of the chlorides and sulfates of sodium, magnesium, calcium and potassium. Due to the high chloride concentration, salt water has a high capacity for depassivation of metals. Seawater metal corrosion flows through the electrochemical process.

The presence of fracture ulcers and pitting shape is specific for the metal destruction in seawater along with the general corrosion. Average rate of steel corrosion in seawater, which is calculated on a weight loss, is from 0.05 to 0.20 mm / year and pitting - 1 mm / year.

The rate of metal corrosion in seawater is influenced by several factors. Thus, the total salinity of the seawater does not affect the intensity of the corrosion process, while some of the deviations from the usual formulation, for example, the presence of hydrogen sulfide or various impurities may increase the corrosion rate.

The motion of seawater increases the rate of oxygen delivery to the cathodic areas of the metal surface, and hence the corrosion rate of most metals. At the same time, the corrosion-resistant steels increase oxygen diffusion results in enhanced surface passivation and protection against pitting. With significant speeds of sea and fresh water may appear corrosion-erosion destruction when the electrochemical corrosion is greatly accelerated as a result of water flow. With fast moving water occurs corrosion, when, along with the corrosion process appears a mechanical destruction of the metal caused by water hammer when closing the vacuum vapor bubbles.

The water temperature in two ways affect the corrosion rate on the one hand, the rise of temperature accelerates the diffusion of oxygen and reaction at the anode and cathode sections. On the other hand it reduces the solubility of oxygen, and hence the corrosion rate.

A metal contact of dissimilar metals in seawater leads the corrosion increase of more electronegative metal destruction and reduction (or suppression) of more positive metal. Conclusion on the corrosion behavior of different metals can be made on the basis of a comparison of the stationary potential in the environment. If you select the wrong contact metals and with lack of protection there is a risk of very significant corrosion damage.

At the rate of metal corrosion in seawater can affect the surface fouling by marine organisms (biocorrosion). On the destruction of carbon and low alloy steels fouling does not have a particularly significant effect, the corrosion can thus to grow (if sulphate-reducing bacteria is present, the event pairs of differential aeration) or decrease (due to the reduction of oxygen and the coating of active ingredient). The impact of fouling on the corrosion of stainless steels, aluminum and copper alloys are also unique, but in general we can say that it is negative. The reason is that these materials are tend to crevice corrosion in the gaps formed by fouling, which enhances the degradation of metal at rupture of the passive film due to the reduced oxygen content.

A sharp increase of metal structures corrosion in seawater, sometimes dozens of times, can take place in the zone of stray currents or leak currents when a metal surface is exposed to strong anodic polarization under the action of flowing current.

UNDERGROUND CORROSION

Soils contain different chemical moisture and have ionic conductivity. It makes them as active corrosive electrolyte in relation to the underground metal structures, which leads to galvanic corrosion.

Characteristic for underground metal constructions is corrosion with forming of deep ulcers that explain, in comparison with other environments, high heterogeneous metal surface owned to unevenness of its hydration and aeration at different portions of the object.

On the corrosivity of the soil affect a number of physical, chemical and biological factors.

One major factor is the structure of the soil, that is, the size, shape and arrangement of the particles, the nature of the connection between them, which determines conditions for the. For example, sandy soils have a relatively low porosity, but the pores are large and easy to pass water and gases. In such soils oxygen easily reaches the surface of buried objects that promotes corrosion, but the water in the sandy soil is not delayed and it inhibits the development of corrosion. Clay soils have significant porosity with thin pores; such soils retain moisture for a long time, however, the flow of oxygen in this case is difficult. These examples show that the corrosion aggressiveness of the soil is determined not only by its moisture, but also on a combination of factors moisture and aeration.

Aggressiveness of soil also depends strongly on the content of various chemicals, especially soluble salts (chlorides, sulfates, nitrates) that increase its conductivity. The specific electrical resistance of the soil is often mistaken for the main criterion of its corrosiveness. This value is really in most cases correlated with the rate of corrosion of metals, however, is not the only criterion for determining the possible corrosion damage of underground metal structures. It should take into account the whole range of factors.

Most of the soil has a neutral or near the reaction (pH = 5-8), but there are soil having acidic (pH = 3-5) or alkaline (pH = 8-10) reaction. With decreasing pH (humic and marshy soil) corrosion activity will increase significantly as the process in this case can occur with hydrogen depolarization, reducing cathodic inhibition.

Soil corrosion can dramatically enhanced (sometimes several times) with the presence of microorganisms, under the action of stray currents due to soil pollution by industrial or domestic waste water.