Lecture № 10

Corrosion control during oil and gas production

Internal and external corrosion of downhole tubing and equipment, subsea or surface pipelines, pressure vessels, and storage tanks is a major problem in the oil and gas industry.

Besides basic wastage of metal, either generally or locally, the consequences (results) of electrochemical corrosion can also be embrittlement and cracking, all of which can lead to equipment failure. Corrosion of iron in steel requires the presence of water and aqueous species that can be reduced while the iron is oxidized.

Oxygen, acid gases such as CO_2, H_2S, and **natural organic acids** in the produced fluids all contribute to corrosion.

Corrosion is an electrochemical redox (reduction and oxidation) process in which localized anodic and cathodic reactions are set up on the surface of the metal.

Entrainment of hydrogen atoms into the metal is one cause of its embrittlement.

Protection against corrosion of inhibitors is based on the ability of inhibitors to reduce the corrosion process speed or completely suppress it when you put them into a corrosive environment in small concentrations. This in turn can improve the reliability and durability of equipment without changing the process technology.

For each type of hostile environment must individually select the appropriate corrosion inhibitor.

Corrosion inhibitors are classified by **type of aggressive environment** and **solubility in the reservoir water.**

There are such types of corrosion inhibitors by the **type of aggressive environment :**

- **hydrogen sulphide corrosion inhibitors;**
- **carbon dioxide corrosion inhibitors;**
- **corrosion inhibitors for neutral environment.**

The effectiveness of corrosion inhibitor is defined by its nature and the nature of the metal exposed to corrosion. It also depends on the properties of the corrosive environment and temperature.

The mechanism of action of inhibitors depends on their chemical composition. Modern corrosion inhibitors in oil and gas industry generally represent a solution of one or more organic compounds which have high qualities inhibitors – also called “active basis”.

The ability of inhibitors to reduce corrosion is mainly due to their action on:

- Kinetics of electrochemical reactions, which are in the process of corrosion;

- Construction of electric double layer;

- The value of electric potential and the metal surface (toward its reduction), which is in the process of corrosion.

By solubility in reservoir water (water and hydrocarbons – gas condensate, oil) such inhibitors are distinguished:

- water soluble inhibitors;
- oil soluble inhibitors;
- inhibitors which are water soluble and dispersible hydrocarbon liquids;
- inhibitors that are soluble in hydrocarbon fluids and water-dispersible;
- inhibitors that are dispersed in water and hydrocarbon liquids.

Acting on the kinetics of electrochemical reactions, inhibitors reduce the corrosion rate. On this basis the corrosion inhibitors *are divided* into **anode, cathode and mixed**.

Anode inhibitors only stop anodic processes, reducing the speed of transition metal ions in solution as a result of passivity. If the corrosion process partially controlled speed cathodic reaction, inhibitor suppresses anodic reaction, reducing the active part of the electrode corrosion intensity may be increased.

This anodic inhibitor can be **dangerous** if its concentration in the solution is small or access to other parts of the equipment is limited.

Cathode inhibitors are safe in all cases, as in any concentration they reduce the rate of corrosion, ionizing oxygen, resulting in the diffusion of oxygen to the cathode charging or oxygen ions. But they are less effective than the anode.

Mixed inhibitors for all types of speed control corrosion process have advantages over the anode, as they are less dangerous and do not lead to an increase in the intensity of corrosion.

The nature of protective action are three types of corrosion inhibitors

Inhibitors of reacting with the **first** type of corrosion products (iron ionsFe_2 + OH- hydroxyl group) to form on its surface a protective film of anodic, cathodic or mixed type. To the first type are inhibitors inorganic (mineral) salt Na_3PO_4 (anode type); MgCl (cathode type); Ca $(HCO_3)_2$ (mixed type) and others.

The second type inhibitors protect metal formation or increase of the metal oxide film on the surface that prevents further leakage corrosion process. These include such oxidants as chromates, nitrites, molybdates, manganates, concentrated solutions of alkali, which uploaded MnO_2, $NaNO_2$ and others.

The third type of organic origin include inhibitors that protect metal from corrosion due to adsorption inhibitor metal surface. The organic film-forming inhibitor mainly used in industrial (field) practice. These include inhibitors of soluble 1-1-B, 2-ANP, I-25-D, IKSH, CI-1, B-katapin 300; I-1-A, ANPO, Donbass, IKAR-1 and others.

Inhibition of wells made in the following ways:

- feeding liquid dosage inhibitors with inhibitors gas processing facility on the wires in the annular space, which comes through the inhibitor valve or circulation pump column in the tubing and packer in the absence - directly on the face well;
- dosed liquid feed inhibitors in the annular space through estuaries inhibitory installations;
- periodic proportional injection of liquid pump inhibitors mobile units through annular space or tubing on the face well;
- periodic injection of inhibitors in liquid or vapor (aerosol) state in the bottomhole formation zone;
- introduction into the well through a special solid lubricator inhibitors.

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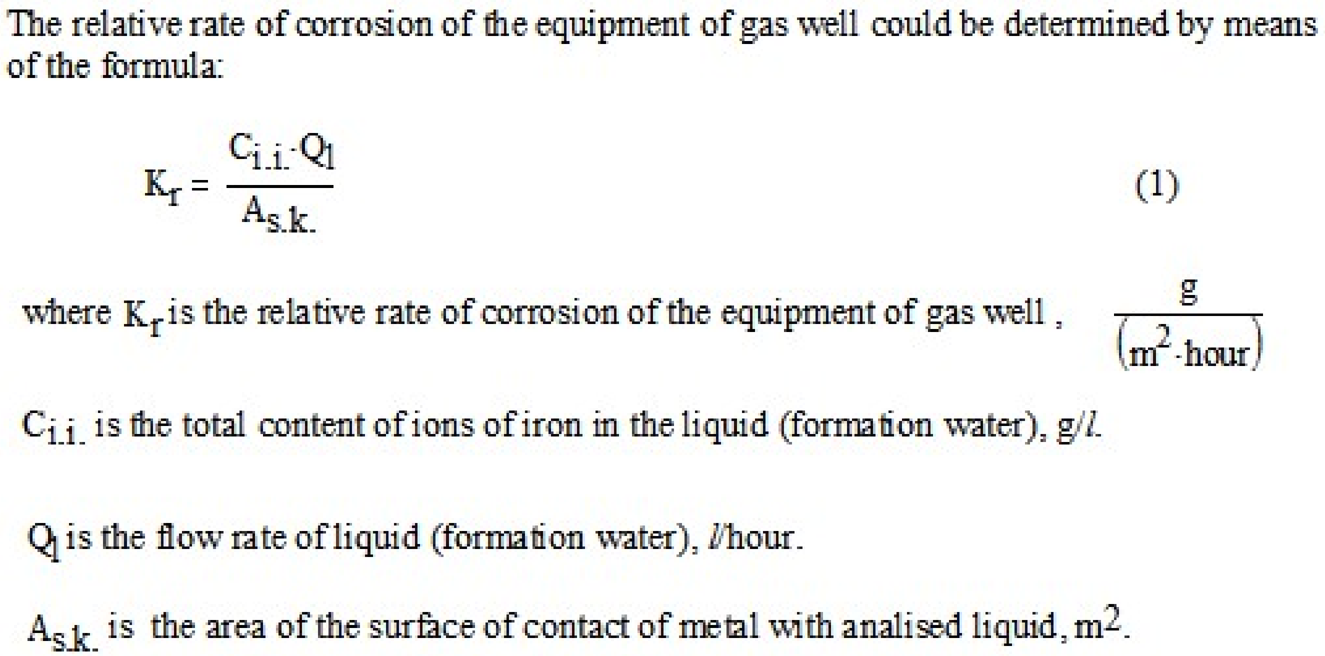
Determination of the relative rate of corrosion of the equipment of gas well:



The relative rate of corrosion of the equipment of gas well could be determined by means of the formula:

$$K_r = \frac{C_{i.i.} \cdot Q_l}{A_{s.k.}} \qquad (1)$$

where K_r is the relative rate of corrosion of the equipment of gas well, $\frac{g}{(m^2 \cdot hour)}$

$C_{i.i.}$ is the total content of ions of iron in the liquid (formation water), g/*l*.

Q_l is the flow rate of liquid (formation water), *l*/hour.

$A_{s.k.}$ is the area of the surface of contact of metal with analised liquid, m^2.