FORMS OF CORROSION

Corrosion - General

Corrosion is a chemical or electro-chemical reaction of unprotected metal surfaces, resulting from aggressive components in the atmosphere or medium - oxygen, humidity, sulfur dioxide, carbon dioxide, organic and hydrochloric acids - as well as over-corrosive liquids and gases - cause destruction and or transformation of the metal particles in salts, oxides, hydroxides and chlorides. All base metals and their alloys, e.g., iron, copper, and zinc, are especially exposed to this destruction - in simplified technical terms, corrosion is the destruction of metal by either chemical or electro-chemical reaction with the environment.

Sweet Corrosion

Corrosion occurring in oil and gas wells where no iron sulfide corrosion products, H2S odor or oxygen exist, it is attributed to carbon dioxide (C02) and organic (fatty) acids. In presence of water, carbonic acid is formed from dissolved C02, iron carbonate is formed, which results in general loss of material and shallow areas of local attack.

Sour Corrosion

This most serious form of pipeline corrosion is caused by hydrogen sulfide, particularly with moisture present, and very severe if C02 or oxygen is also present. H2S dissolved in water reacts with steel in forming iron sulfide which, depending on PH-values, may either be soluble or insoluble.

This kind of corrosion may also result in metal loss and can quickly lead to cracking (SCC and/or H.I.C., depending on type of steel).

Pipelines containing H2S and C02 can pit in water phase.

Oxygen Corrosion

Is caused by the action of 02 dissolved in water and occurs wherever equipment is exposed to atmosphere, causing loss of metal and creating iron hydroxide - resulting in extreme pitting. The most common form is rusting of steel - corrosion rate depends on temperature, humidity (water is acting as electrolyte) and is usually more severe in salt water than in fresh water. Oxygen corrosion is very frequent on offshore installation - it is most critical in the splash zone + fairly uniform in submerged zone. Oxygen corrosion is also common in water injection and brine handling systems.

The oxygen content of normal seawater ranges from 6 -10 ppm between temperatures of 4 to 32°C., which is adequate to maintain a passive film on stainless steels, when the water flow over the surface exceeds 1.5 m/sec. If the flow velocity is lower, it is possible for debris, silt, and fouling organisms to collect on the surface of the stainless steel and to establish crevices which limit or even eliminate the supply of oxygen to the surfaces. When seawater is moving at high velocities past stainless steel surfaces, virtually no corrosion takes place.

Electro-Chemical Corrosion

Also referred to as "electrolysis" - occurs in two forms - one which is somewhat like a reversed plating reaction, caused by stray direct electric currents flowing from the steel anode to a cathode or, second, when pipe is exposed to certain types of moist soil.

Bimetallic Corrosion

Often called 'galvanic corrosion" - is another form of electro chemical corrosion. This type of corrosion is quite common in subsurface well equipment and results from the discharge of electric currents generated by reaction of dissimilar metals immersed in an electrolyte.

Contact Corrosion

Also called "bi-metallic corrosion", occurring between assembled components, consisting of different metals (copper and iron, aluminum and brass).

Crevice Corrosion

Is found on identical materials under heads of screws and bolts, in bolted joints, and is generally due to uneven ventilation.

Fatigue Corrosion

Describes the failure of a metal part by cyclic loading in a specific environment in a lower number of cycles or at a lower stress than would have been required in air at room temperature

Pitting is a type of localized corrosion that occurs when a small area of metal is anodic to the surrounding metal. This type of corrosion is generally caused by oxygen.

Weight Loss Corrosion

With the search for oil and gas moving into deeper formations, more H2S and C02 are produced. Due to the presence of formation water and condensates, the H2S and C02 form sulfuric and carbonic acid resulting in weight loss corrosion.

Weight loss corrosion can vary considerably, depending on the exact composition, the chlorine content, the velocity and the temperature.

Stress Corrosion Cracking (SCC)

SCC is a brittle failure made in which a susceptible alloy under a tensile load cracks as a result of interaction with a specific environment. SCC will only occur with certain combinations of alloy and environment.

Hydrogen Sulfide Corrosion

Damage caused by this corrosion is generally a result of three separate actions :

1 - A direct action of sulfide, resulting in a characteristic black scale or powder.

2 - A galvanic action between the sulfide scale and steel, where the steel is acting as an anode and corroding in pits.

3 - Embrittlement of steel - as a result of the action of sulfide on steel, hydrogen is liberated, migrates into the steel, where it either combines with itself forming molecular hydrogen or alloys with the carbon compounds of the steel, causing very high internal stresses that lead to the embrittlement of steel - cracks and blisters (hydrogen induced cracking - HIC).

MISCELLANEOUS

Carbon equivalent

Formula which identifies highly weldeable low carbon steels, which do not require post weld heat treatment :

$$CE = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15}$$ 0.40 - 0.45 is generally acceptable.

Hydrogen Sulfide (H2S)

H2S is a highly toxic and extremely dangerous, colorless, gas that is heavier than air (1.192 Sp. Gr.)and has at low concentrations the odor of rotten eggs. It also deadens the sense of smell - exposure toH2S can be fatal !!

The gas burns with a blue flame and produces sulfur dioxide (S02),forms an explosive mixture with air between 4.3 and 47 volume percent's and is soluble in water.

Partial Pressure

Total pressure X percent H_2S or CO_2.

Useful factor to predict corrosivity of oil and gas wells :
A partial pressure of CO_2 above 30 psi usually indicates corrosion - 7 to 30 psi may indicate corrosion- below 7 psi, no corrosion danger.

PH Value

A factor signifying the concentration of hydrogen.

The lower the PH (more acidic), the higher the concentration of hydrogen ions - the higher the PH- value (more basic), the lower the concentration of hydrogen ions (1-7 acidic, 8-14 basic). PH-7 indicates a neutral solution (pure water).