CORROSION PROTECTION METHODS

There are many methods to reduce corrosion in all types of structures. Specifically in steel pipelines there are three main types: coatings, corrosion inhibitors and cathodic protection.

Coatings

Coatings provide physical barriers that do not allow corrosive materials to come in contact with the structure that is being protected. Mainly, coatings are used on the exterior of pipelines to protect from external factors and are not used to directly protect the pipeline from CO2 corrosion. The most common type of coatings are painting and platting which both provide effective corrosion protection and aesthetic appearance.

Painting: Painting is an effective way to protect pipelines from external environmental factors. Although when looking at CO2 corrosion on the interior of the pipeline, it is not ideal because painting the inside of a pipeline is impractical. The paint will breakdown over time, either through chemical reactions with the flowing fluid or the erosion due to turbulent or transient flow. Once the coating has broken down it leaves unprotected sections of the pipe when fluid induced localized corrosion occurs.

Plating: Plating involves using electric currents to coat a metal with a thin layer of another metal that acts as a protective barrier. Plating an entire pipeline is very uncommon as it is expensive; however, it can be done when dealing with high pressures and high amounts of H2S and CO2. One draw back of plating is if the plating fails in a small section (either an imperfection or a scratch) then highly localized corrosion occurs. Another factor to consider is if the plating is more noble than the pipeline (for example, chromium on steel), the steel will act as a sacrificial anode for the chromium. This causes the exposed area to corrode much more rapidly than an un-plated surface would.

Corrosion Inhibitors

Corrosion inhibitors offer corrosion protection that is similar to coatings as they act as a barrier between the oxidizing agents and the metal surface. The inhibitor adsorbs onto the steel surface and slows down or eliminates one or more of the electrochemical reactions by blocking the reaction site. The degree of protection that a corrosion inhibiter provides is heavily dependent on the properties of the inhibitor, the properties of the steel and the fraction of the steel surface that is blocked by the inhibitor.

Liquid phase inhibitors (LPIs): LPIs are in wide scale use to combat CO2 corrosion in pipelines. The inhibitor is that is injected into the pipeline is transported in low

concentrations and adsorbs onto the surface of the steel. Because the inhibitor is in the liquid phase only the interior of the pipeline needs to be in contact with the liquid either continuously or semi-continuously. One of the main benefits in using inhibitors to protect from CO2 corrosion is that it can continuously be added to the flow to provide continuous protection.

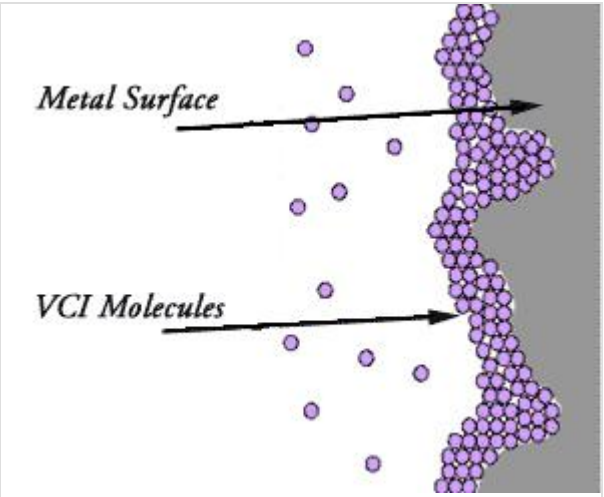

Figure 1: VCI Molecules Adsorbing to a Metal Surface

Volatile corrosion inhibitors (VCIs): VCIs are similar to liquid phase inhibitors in that they are present in low concentrations in the pipeline. Because they are a volatile compound they can easily enter the vapour phase if one is present. VCIs can adsorb onto the steel directly from the vapour phase and can penetrate into complex shapes and imperfections better than LPIs. Any condensate that may form on the inside of the pipe may contain water and CO2 which will contribute to corrosion in the pipe. If VCIs are present in the vapour phase they will also condense and provide a protective film.

The volatility of the inhibitor is dependent on the vapour pressure of the compound. For the prevention of CO2 corrosion on steel, amines are used as the VCI. The vapour pressure of amines is ideal so that the VCI will be present in both phases and provide ideal coverage for the pipeline.

Cathodic Protection

Sacrificial Anode: A sacrificial anode is used to protect metal structures,

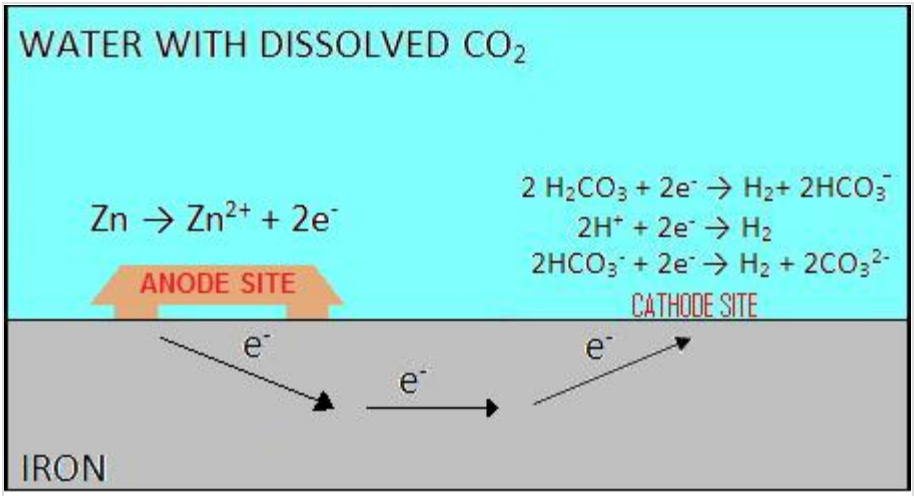

Figure 2: Iron Protected With Sacraficial Anode

mainly iron, from corrosion. A sacrificial anode is a substance that is easier to oxidize then the structure being protected, typically it is a relatively small and easy to replace piece of metal. From the standard electric potentials below:

Fe(s) <-> Fe2+ + 2e- + 0.44
Zn(s) <-> Zn2+ + 2e- + 0.76
Mg(s) <-> Mg2+ + 2e- + 2.37

Both magnesium (Mg) and zinc (Zn) have higher potentials so they will be oxidized before iron if they are connected in a system. When either magnesium or zinc anodes are connected to an iron structure electrons will move from the sacrificial anode through the iron structure and to the reduction reaction site. This causes the iron structure to retain its electrons and not corrode until the anode has been used up.

Sacrificial anodes are used when the pipeline is temporary or where there is not access to a power supply.

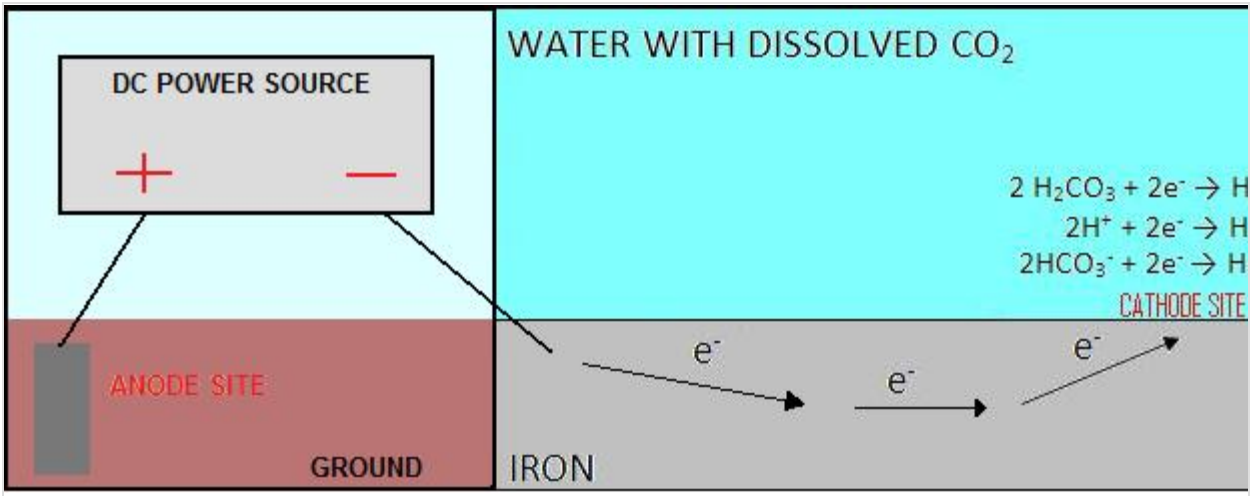

Figure 3: Iron Protected With ICCP

Impressed Current Cathodic Protection (ICCP): This form of corrosion protection is applied by connecting the negative terminal of a DC power source to the iron structure and the positive terminal to an anode. Because the driving voltage is provided from a DC source and not electric potentials the anode does not need to oxidize and an inert anode can be used. There are 3 main advantages to using ICCP, one being that the DC power sources can provide much higher driving voltages then sacrificial anodes (100 to 10,000 times higher) and can protect larger areas. The second main advantage is that the anodes that are used, such as graphite, are inert and don't need to be continuously replaced. The final advantage is the degree of control over the electron transfer that ICCP has, the current can be increased or decreased as need be.

ICCP is what is typically found on all pipelines as it does not have to continuously monitored like the sacrificial anode and there is more control over the electron flow.

Source : http://co2corrosionchem409.wikispaces.com/Corrosion+Protection+Methods