

The Lease Pumper's Handbook

CHAPTER 16

CORROSION, SCALE, AND CATHODIC PROTECTION

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Chapter 16 Corrosion, Scale, and Cathodic Protection

Section A

CORROSION AND SCALE

The purpose of this chapter is to assist the lease pumper in understanding corrosion and how to reduce the damage it causes in wells and surface facilities. In addition, this chapter provides a basic overview of scale and scale control for wells that produce a lot of water. Examples of corrosion and scale problems are shown in Figures 1 and 2.

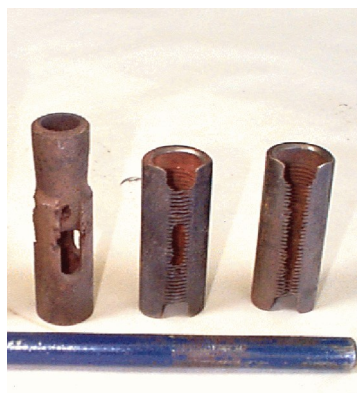


Figure 1. Note corrosion on left item, a downhole pump part, and a parted rod.



Figure 2. Scale in a cut-out section of tubing showing how it is deposited inside the unprotected pipe.

A-1. Introduction to Corrosion.

Corrosion is a general term for a reaction between a metal and its environment that causes the metal to breakdown. While there are many types of corrosion, they all involve either a chemical reaction or an electrochemical reaction. In chemical reactions, chemicals in the environment react with the metal to create different chemicals. Thus, atoms or molecules of the metal combine with other atoms or molecules that contact the metal to form different, generally weaker, materials. Rust is an example of this type of corrosion.

In electrochemical corrosion, the environment around the metal results in the creation of an electrical current, which is simply a flow of electrons. The metal corrodes by giving up electrons to create the electrical flow.

The oil field environment is filled with metal pipes and other components that often exposed to chemicals that can cause corrosion, especially when the metal and chemicals are in a solution such as downhole fluids. The pumper must understand how to reduce corrosive damage to the metal in wells, flow lines, tank batteries, and equipment.

There are four general types of corrosion of concern in the oil field. These involve three chemicals of concern and electrochemical corrosion. The types of corrosion include:

- Carbon dioxide (sweet corrosion)
- Hydrogen dioxide (sour corrosion)
- Oxygen corrosion (oxidation)
- Electrochemical corrosion

A-2. Carbon Dioxide Corrosion.

Carbon dioxide (CO_2) is a corrosive compound found in natural gas, crude oil, condensate, and produced water. CO_2 corrosion, or *sweet corrosion*, is common in the oil fields in southern Oklahoma, New Mexico, the Permian Basin of Texas, and the Continental Shelf along the Gulf of Mexico because of the high CO_2 content of the crude from these areas. Special refineries capable of refining high CO_2 crude oil are expensive to build and maintain. Most of these refineries in the U.S. are clustered in the Gulf Coast area. Much of the crude oil from Alaska must be refined in this area because it also contains a large amount of CO_2 .

CO_2 is composed of one atom of carbon with two atoms of oxygen. When combined with water (H_2O), carbon dioxide produces carbonic acid (H_2CO_3). Carbonic acid causes a reduction in the pH of water and results in corrosion when it comes in contact with steel. When iron (Fe) combines with carbonic acid, it produces iron carbonate (FeCO_3). Iron carbonate is not as strong as the refined iron or steel used to make the well components.

The damage caused by sweet corrosion in oil wells usually results in pitted sucker rods and the formation of hairline cracks. Corrosion *test coupons* can be inserted into the lines to indicate the level of iron removal and other corrosive conditions. Caliper surveys can also be used to determine the extent of tubing damage. Chemical injection, alloys, and protective coatings are used to combat the problem.

A-3. Hydrogen Sulfide Corrosion.

Hydrogen sulfide (H_2S) occurs in approximately 40% of all wells. The amount of H_2S appears to increase as the well grows older. H_2S combines with water to form sulfuric acid (H_2SO_4), a strongly corrosive acid. Corrosion due to H_2SO_4 is often referred to as *sour corrosion*. Since hydrogen sulfide combines easily with water, damage to stock tanks below water levels can be severe.

Solutions to sour corrosion problems are similar to those for sweet corrosion. This includes the use of chemicals, alloys, and coatings to combat the problem and reduce the damage. Circulating chemical down the annulus is a common practice to treat downhole problems.

When sufficient amounts of H_2S are produced with the emulsion, the pumper must wear a gas mask when gauging or *working oil*—that is, testing oil at the thief hatch to determine if it is ready for sale (Figure 3).



Figure 3. Where H_2S gas is present, sour corrosion is likely and breathing apparatus is required.

A-4. Oxygen Corrosion.

Oxygen corrosion or *oxidation* is the most common form of corrosion. On steel and iron, oxidation typically takes the form of rust. Painting the tank battery and other surface equipment to eliminate this contact is basic oxygen corrosion protection.

Oxygen corrosion begins when equipment makes contact with the atmosphere and moisture. Under these conditions, the iron and oxygen react with each other to form ferric oxide (Fe_2O_3), which is commonly referred to as rust. Oxidation can also occur with other metals, including aluminum. Although the compounds formed will be different, the results are the same in that the metal is weakened, usually undergoing embrittlement in which the metal becomes brittle. Oxidation can also accelerate the damage from sweet corrosion.

An oil blanket is often deliberately maintained on produced water to block the atmospheric oxygen from contacting the water. A system that prevents the atmosphere from making contact with the produced water is referred to as a *closed system*. A system that allows the air to contact the produced water is referred to as an *open system*. Stripper wells are often produced with the casing valve open to the atmosphere, which promotes downhole corrosion. Water flood can also inject oxygen into the formation, promoting oxidation. Open systems are sometimes preferred because the formation of rust can actually help to protect against some forms of corrosion, such as electrochemical corrosion described later.

A-5. Electrochemical Corrosion.

There are two common types of electrochemical corrosion. One is the result

of electrical current leaking into the environment. Electrical current may be planned to power electrical equipment or it may be generated accidentally, such as the static electricity produced by the wind blowing. Corrosion can occur wherever the electrical current leaks into the environment. For example, poor grounding may allow stray current to enter a pipe. When the current reaches a wet area, the current may flow from the pipe. Electrochemical corrosion is likely to occur at that point.

The second type of electrochemical corrosion is more common. It occurs when metal in water, such as downhole parts or pipe laid in moist soils, becomes part of an electrical cell. Such a cell is essentially an acid battery and will be formed just about any time two different types of metals are placed in an acidic solution. Electrons from one metal will flow to the other metal. This results in the metal that gives up electrons being eaten away and the other metal building up a brittle coating. The metal that gives up electrons and corrodes away is referred to as the *anode*, and the metal that collects electrons is called the *cathode*.

Techniques that are implemented to slow down or eliminate electrochemical corrosion are referred to as *cathodic protection*. In cathodic protection, the flow of electrical current is altered to prevent the metal to be protected from serving as an anode.

A-6. Problems with Scale.

Scale, or *gyp*, is carried with water in a solution and migrates toward the well bore. Problems with scale can begin as it approaches the matrix or well bore area. It can plug the formation, casing, and tubing perforations; make tubing in the hole stick; fill tubing to the point that the pump cannot be pulled without stripping; and plug flow

lines. At the tank battery it can fill lines and vessels and accumulate in the bottom as a solid. Scale can accelerate electrochemical damage by acting as a cathode to the steel, resulting in deep pitting.

Stopping scale in the formation and chemical treatment. The first place to solve problems with scale is in the formation. Chemicals are available that can be blended with water and pumped into the formation to stabilize the scale and highly reduce its accumulation in the system. It may be necessary to acidize the wells periodically to clean up the immediate reservoir area and to reopen the casing perforations. Special small materials that are water- or oil-soluble can be blended into the fracturing compounds to control the process and increase the efficiency of the treatment.

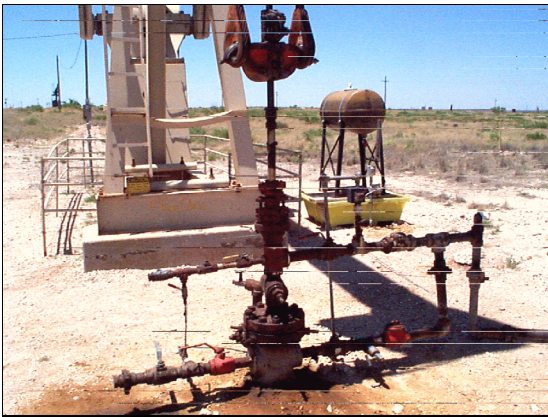


Figure 4. The chemical tank (background) and the pump and injection tee (left of wellhead) are used to combat scale with chemicals.

Protective coatings. Special coatings can be applied to reduce the ability of scale to cling to the inside of the tubing. With flowing wells, this coating may be applied like paint. On pumping wells the rod action would damage the coating. Consequently, special chemicals can be circulated down the

casing that are produced back up through the tubing to protect perforations, tubing, and the downstream flow line and tank battery. This treatment can be a continuous or periodic batch treatment.

Scale removal. When systems are permitted to fill with scale, it may be necessary to disassemble, clean, and rebuild of the system. A good and efficient scale control program must be maintained.

Scale can be reduced and removed by slow and expensive chemical processes. Scale accumulation in tubing can also be scraped or drilled out. In vessels, it may require the removal of the manway plates, entering the vessel with the proper safety equipment, and physically shoveling the accumulation out.

Problems with scale caused by construction practices. Good construction practices should always be followed to prevent building systems that trap scale and cause unexpected problems. As an example, the line from the wellhead to the tank battery should not contain any 90-degree bends. Even an ell in the line may not be satisfactory. Pipe can be bent or slow curves installed to eliminate any scale traps between the well and the tank battery.

A-7. Other Types of Corrosion

Many environmental factors can influence the effects of corrosion. The chemical content of the soil and the production fluid, the climate, the materials used for well components, and other factors have an effect. The presence of microorganisms can accelerate corrosion, and microbiological corrosion in which organisms eat the materials or chemically transform them is also common.