

Corrosion Types Encountered With Power Cables

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Introduction

There are numerous types of corrosion, but the ones that are discussed here are the ones that are most likely to be encountered with ***underground power cable facilities***.

In this initial explanation, lead will be used as the referenced metal. Copper neutral wire corrosion is not discussed here.

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Anodic Corrosion (Stray DC Currents)

Stray **DC currents** come from sources such as ***welding operations***, flows between two other structures, and –in the days gone by – street railway systems.

Anodic corrosion is due to the transfer of direct current from the corroding facility to the surrounding medium,

usually earth. At the point of corrosion, the voltage is always positive on the corroding facility.

In the example of lead sheath corrosion, the lead provides a **low resistance path for the DC current** to get back to its source. At some area remote from the point where the current enters the lead, but near the inception point of that stray current, the current leaves the lead sheath and is again picked up in the normal DC return path.

The point of entry of the stray current usually does not result in lead corrosion, but the point of exit is frequently a corrosion site.

Clean sided corroded pits are usually the result of anodic corrosion. The products of anodic corrosion such as oxides, chlorides, or sulfates of lead are carried away by the current flow. If any corrosion products are found, they are usually lead chloride or lead sulfate that was created by the positive sheath potential that attracts the chloride and sulfate ions in the earth to the lead.

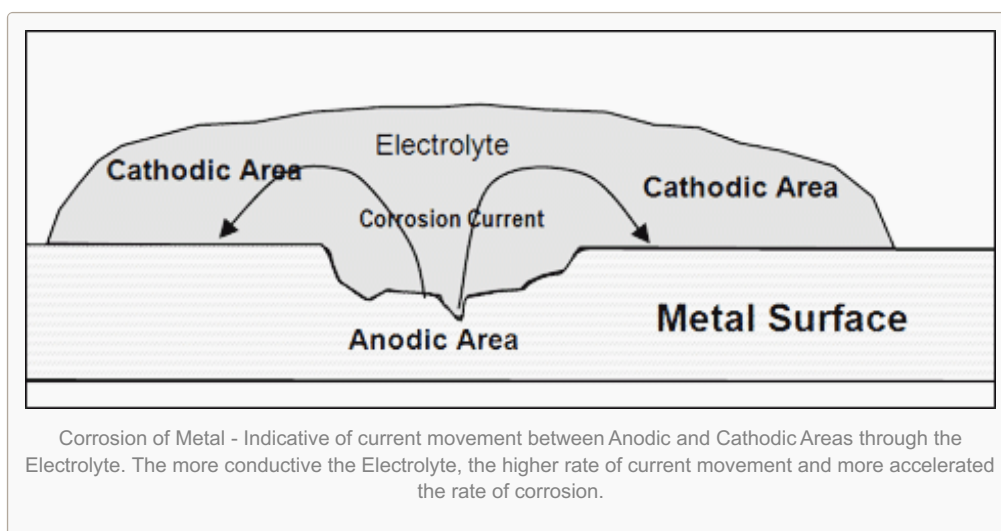
In severe anodic cases, **lead peroxide** may be formed. Chlorides, sulfates, and carbonates of lead are white, while lead peroxide is chocolate brown.

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Cathodic Corrosion

Cathodic corrosion is encountered less frequently than anodic corrosion, especially with the elimination of most street railway systems.

This form of corrosion is usually the result of the presence of an alkali or alkali salt in the earth. If the potential of the metal exceeds **-0.3 volts**, cathodic corrosion may be expected in those areas.



In cathodic corrosion, the metal is not removed directly by the **electric current**, but it may be dissolved by the secondary action of the alkali that is produced by the current. Hydrogen ions are attracted to the metal, lose their charge, and are liberated as hydrogen gas.

This results in a decrease in the hydrogen ion concentration and the solution becomes alkaline. The final corrosion product formed by lead in cathodic conditions is usually lead monoxide and lead / sodium carbonate. The lead monoxide formed in this manner has a bright orange / red color and is an indication of cathodic corrosion of lead.

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Galvanic Corrosion

Galvanic corrosion occurs when two dissimilar metals in an electrolyte have a metallic tie between them.

One metal becomes the **anode** and the other the **cathode**. The anode corrodes and protects the cathode as

current flows in the electrolyte between them. The lead sheath of a cable may become either the anode or the cathode of a galvanic cell.

This can happen because the lead sheath is grounded to a metallic structure made of a dissimilar metal and generally has considerable length.

Copper ground rods are frequently a source of the other metal in the galvanic cell. The corrosive force of a galvanic cell is dependent on the metals making up the electrodes and the resistance of the electrolyte in which they exist. This type of corrosion can often be anticipated and avoided by keeping a close watch on construction practices and eliminating installations having different metals connected together in the earth or other electrolyte.

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Chemical Corrosion

Chemical corrosion is damage that can be attributed entirely to chemical attack without the additional effect of electron transfer.

The type of chemicals that can disintegrate lead are usually strong concentrations of alkali or acid.

Examples include alkaline solutions from incompletely cured concrete, acetic acid from volatilized wood or jute, waste products from industrial plants, or water with a large amount of dissolved oxygen.

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AC Corrosion

Until about 1970, **AC corrosion** was felt to be an insignificant, but possible, cause of **cable damage**.

In 1907, Hayden reporting on tests with lead electrodes, showed that the corrosive effect of small AC currents was less than 0.5 percent as compared with the effects of equal DC currents. Later work using higher densities of AC current has shown that AC corrosion can be a major factor in concentric neutral corrosion.

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Local Cell Corrosion

Local cell corrosion, also known as differential aeration in a specific form, is caused by electrolytic cells that are created by an inhomogeneous environment where the cable is installed.

Examples include variations in the concentration of the electrolyte through which the cable passes, variations in the impurities of the metal, or a wide range of grain sizes in the backfill. These concentration cells corrode the metal in areas of low ion concentration.

Differential aeration is a specific form of local cell corrosion where one area of the metal has a reduced oxygen supply as compared with nearby sections that are exposed to normal quantities of oxygen.

The low oxygen area is anodic to the higher oxygen area and an electron flow occurs through the covered (oxygen starved) material to the exposed area (normal oxygen level).

Differential aeration corrosion is common for underground cables, but the rate of corrosion is generally rather slow. Examples of situations that can cause this form of corrosion include a section of bare sheath or neutral wires

that are laying in a wet or muddy duct or where there are low points in the duct run that can hold water for some distance.

A cable that is installed in a duct and then the cable goes into a direct buried portion is another good example of a possible differential aeration corrosion condition.

Differential aeration corrosion turns copper a bright green.

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Other Forms of Corrosion

There are numerous other forms of corrosion that are possible, but the most probable causes have been presented. An example of another form of corrosion is microbiological action of anaerobic bacteria which can exist in oxygen-free environments with pH values between 5.5 and 9.0.

The life cycle of anaerobic bacteria depends on the reduction of sulfate materials rather than on the consumption of free oxygen. Corrosion resulting from anaerobic bacteria produces sulfides of calcium or hydrogen and may be accompanied by a strong odor of hydrogen sulfide and a build-up of a black slime.

This type of corrosion is more harmful to steel pipes and manhole hardware than to lead sheaths.

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Resource: *Electrical Power Cable Engineering – William A. Thue*

Source:

<http://electrical-engineering-portal.com/corosition-types-power-cables>