
Corrosion Protection for Tower Structures

Technical Note

Coaxial Cable Protection

Corrosion Protection for Tower Structures

Most people have a tendency to use copper as for grounding because it is a good conductor, and one of the more noble metals. However, it does have a significant drawback. Since it is near the upper end of the table of noble metals, copper when put in direct contact with most common metals, which are lower in nobility, will cause accelerated corrosion of the lesser metal. The significance of being more noble means any other metal buried and connected to your copper ground system will become sacrificial. (Also see Topic: Dissimilar Metals.)

A galvanized (hot dipped zinc) tower on a rebar reinforced concrete base is not at risk with a copper ground system.. Since concrete is conductive and forms a Ufer ground, and rebar is a very hard (heat treated) steel which will rust, the rust on the surface of the rebar, which is a non-conductive oxide when dry, will prevent further oxidation. Since concrete readily retains moisture for long periods of time, the rust is a fairly good conductor. Further corrosion reduction to the rebar, due to galvanic action, will be limited by this oxide layer.

A buried galvanized tower section (not the “J” bolts) or guy anchor embedded in concrete will have some galvanic currents that could cause the depletion of the zinc coating into the concrete. This will leave exposed steel that will continue to pit and may even de-alloy. This type of corrosion may take 20 to 30 years or more before the structural failure of the tower may occur.

In 1990, several towers were lost in Minnesota alone due to guy anchor corrosion and failure. Some contractors and manufacturers have now gone to the extent of tar/pitch dipping the anchors so this galvanic corrosion does not occur. This means that the anchor is now insulated from the surrounding Ufer ground! Proper guy wire and anchor grounding is essential under these (or any) circumstances. An improperly grounded insulated guy anchor can arc through the anchor’s pitch coating, cracking the concrete with resulting structural failure.

The better the soil conductivity, the more galvanic corrosion could occur. Doping soil with salts can increase the speed of the corrosion. Consequently, it is better to have an extensive radial and ground rod system rather than a smaller ground system with doped soil.

For existing towers, look at the ratio of surface areas and ground resistance. The current density for a given current will be greater for material with a smaller surface area. The more extensive the copper grounding system close in around the anchor or tower base, the more the current density and galvanic corrosion on the anchors or tower base for a given earth resistance.

If you follow the recommended PolyPhaser method of using radials and ground rods that lead away from the tower base, guy anchors, and equipment building, the resultant distributed surface area and current must return through ever increasing ground distance/resistance. This makes the currents smaller than a ground system using concentric rings or a ground grid.

It may appear obvious that the use of similar materials would eliminate the galvanic problem. While this is true, galvanized ground wire and ground rods are not normally recommended since the electric utility company will probably use a copper clad steel ground rod. Replacing the utility rod may be dangerous or impractical.

Another alternative is to install an active cathodic protection system. The system consists of a power supply (lightning protected of course) and a buried sacrificial anode element, such as zinc. The power supply will electrically elevate the tower section or anchor (negative) forcing galvanic currents through the sacrificial zinc anode (positive) element. The anode will deplete over time in the soil instead of your tower and guy anchors. If magnesium were substituted for zinc, the power supply can be eliminated since magnesium is more anodetic than galvanized steel.

The following affect the amount and speed of corrosion both above and below the soil:

- 1) **Water.** The presence of water mixed with contaminants is the basis of galvanic corrosion. Pure rain water is slightly acidic (pH 5.5 to 6.0). It picks up carbon dioxide as it falls which creates carbonic acid. It can start attacking some metals, even copper, without being in a junction. The ions etched from the copper go into solution in the rain water. As this rain water drips on galvanized tower sections, it will cause the zinc to combine and wash off. This leaves the bare steel to oxidize away.
- 2) **Oxygen.** This is the main corrosion accelerator. Rain water also picks up oxygen as it falls through the atmosphere. Water provides an excellent carrier of oxygen.
- 3) **Temperature.** Generally, the higher the temperature the faster the chemical reaction.
- 4) **Texture of the metal(s).** Glass smooth surfaces are less likely to corrode than rough finishes.
- 5) **Hydrogen Sulfide.** A gaseous product of exhaust emissions, it combines with rain water creating acid rain.
- 6) **Chlorine.** Tap water can have an acidic effect on underground materials.
- 7) **Inert gases.** Helium displaces oxygen and reduces the corrosive effect.
- 8) **Alkaline.** Although some alkalis tend to increase the rate of carbon dioxide absorption from the air, which creates corrosive carbonate solutions, slight amounts of alkalinity can reduce corrosion rates.
- 9) **Salts.** Sodium chloride, found just about everywhere, increases the soil conductivity and also increases the corrosion process in nearly the same proportion to its concentration. Other naturally occurring salts or non natural added salts do the same. Only sodium carbonate or phosphate and potassium ferricyanide form a protective film that prevents further corrosion.
- 10) **Microorganisms.** Both bacteria and fungus can deteriorate metal. Some will give off acids in trapped water or when they die and decompose into acids.

Types of Corrosion

There are several types of corrosion. Listed below are the common names given for descriptive purposes:

- 1) **Uniform Etch:** A direct chemical attack from salts, urine and acids. If allowed to continue, a polished surface will dull and then take on a rough or frosted appearance.
- 2) **Pitting:** Tiny pin holes from localized chemical or galvanic attack.

- 3) **Inter-granular:** Usually galvanic, this is a selective attack along the grain boundaries of an alloy metal. We have referenced this as “de-alloying.” Typical corrosion-resistant alloys can break down when corrosion actually works on the individual components of the alloy.
- 4) **Exfoliation:** Found on extruded metals, the corrosion occurs just below the metal surface and causes a blister to form. This appears where the extruding dyes have forced the crystal structure of the metal to change direction.
- 5) **Galvanic:** The classic two dissimilar metal connection with a water electrolyte bridge is the most basic of corrosion problems.
- 6) **Concentration Cell:** As the amount of oxygen reaching the electrolyte varies, the rate of corrosion will vary accordingly. High concentrated areas of oxygen will have high levels of corrosion.
- 7) **Stress:** More corrosion will occur where high tensile stress is applied. This is where metal is bent or where rivets have been driven. Metals that have been cold worked (bent back and forth several times - copper is easily cold worked) should be annealed (stress relieved by heating). Stress corrosion appears as a crack running parallel to the metal grain.
- 8) **Fatigue:** Another form of stress corrosion where pits are defined along the grain. Additional stress begins to concentrate around them and cracking occurs at the bottom of the pits.
- 9) **Filiform:** Thread-like filament corrosion occurring under painted surfaces where water and oxygen have penetrated and form a corrosion concentration cell.

Helpful Hints

Mother Nature will see that nothing we place in the soil will last forever. But we can do our part to design a grounding system that lasts.

Use all similar metals in your grounding system. If copper is used, don't mix in tin plated copper wire.

On mechanical compression joints, copper joint compound should be used to cover the hardware. This will prevent corrosion that can cause a loss of compression strength and increase joint resistance over time. The joint compound, a petroleum based product with conductive copper flakes, displaces water, oxygen, acids and salts.

Exothermic connections should be allowed to cool slowly to prevent stress corrosion.

A grounding system should be tested annually.

Grounding systems should also be checked annually for corrosion.

Know your soil's pH (See section on soil pH). If acidic, either correct it to neutral or suffer the consequences.