

Q: I know it is not a good practice to have dissimilar metals in contact when the metals are subjected to atmospheric exposure, but is it also important to isolate dissimilar metals when they are embedded in concrete?

A: Galvanic corrosion presents a problem for hot-dip galvanized steel, whether the dissimilar metals are subject to atmospheric exposure, or when embedded in concrete, because the zinc coating sacrifices itself for a metal other than the base steel, which it was designed to protect. Let's review some background information on galvanic corrosion due to dissimilar metals being in contact.

For galvanic corrosion to occur, four things are necessary: an anode, a cathode, an electrolyte, and a return path for the current. When all four are present, a corrosion cell is created (Figure 1) and galvanic corrosion can occur. The anode and cathode are metals with differing electrical potentials. The anode is the metal with a more negative electrical potential and the cathode has a more positive electrical potential. The anode will sacrifice itself for the cathode when the two metals are in contact and are in the presence of an electrolyte, such as rain water, and there is return path for the current.

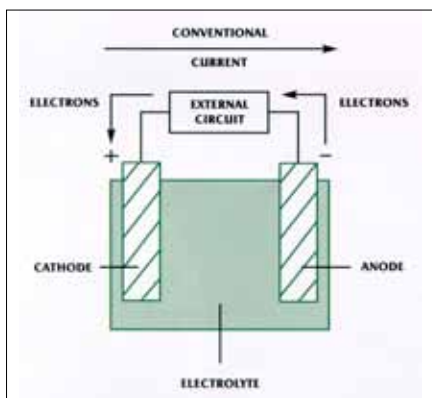


Figure 1

The galvanic series (Figure 2) lists metals that range from more anodic (less noble) to metals that are more cathodic (more noble). The farther apart the metals are on the galvanic series, the greater the electrical potential difference, which can influence galvanic corrosion. There are some instances where dissimilar metals do not have as great a potential difference as would be indicated by the galvanic series. For example, some metals, such as aluminum and stainless steel, may develop a passive layer on their surfaces that can act as an electrical insulator when in contact with a dissimilar metal.

Probably the most important factor in determining the severity of galvanic corrosion is the size of the surface area of the anode and the cathode. When the surface of the anode (say, hot-dip galvanized steel) is relatively large compared to the cathode (say, black steel) the galvanic corrosion rate is low. However, when the surface area of the cathode is greater than that of the anode, galvanic corrosion is high and will consume the anode material. So how does all this information relate to galvanic corrosion due to dissimilar metals being in contact while embedded in concrete?

If black reinforcing bar (rebar) and hot-dip galvanized rebar are in contact in the presence of an electrolyte, even while embedded in concrete, the galvanized coating could sacrifice

itself for the connected black rebar rather than protecting the rebar below the galvanized coating. This could decrease the service life of the galvanized steel by causing the galvanized coating to be consumed faster than would normally be expected.

Water that has chlorides or other minerals can have a much higher corrosion current than pure water and thereby increase the corrosion current that runs between the dissimilar metals. This is very important to understand in terms of rebar embedded in concrete because road salts are commonly used in many areas of the country. When road salts mix with rain or melting snow, the electrolyte created has a high potential to influence galvanic corrosion if a corrosion cell were present in the concrete. Electrolytes from road salts and melting snow or rain can reach the rebar through cracks in the concrete. The same principle applies when the rebar is embedded in any exposed concrete structure such as stairs, sidewalls, garages, walls, barriers, or stadiums.

The easiest way to prevent galvanic corrosion is by electrically isolating the two metals in contact. If there is electrical isolation between the two metals, then there can be no corrosion cell and therefore no galvanic corrosion. In the case of rebar, this means isolating the hot-dip galvanized rebar and fasteners from that of black steel. This can be done using tapes that electrically isolate the metals from one another. Another method to prevent galvanic corrosion is to place the rebar well below the surface of the concrete so it is very unlikely to encounter electrolytes, such as road salt-laden water. If the two dissimilar metals are touching and there is no electrolyte, then there is little chance for galvanic corrosion. Lastly, galvanic corrosion can be reduced or eliminated by maintaining proper surface area ratios between anodes and cathodes. If the anode has a much larger surface area than the cathode, there may be some galvanic corrosion, but the rate will be very low.

In conclusion, galvanic corrosion can still be a concern when hot-dip galvanized steel is embedded in concrete, but there are several methods to prevent it. If you would like to learn more about embedding hot-dip galvanized rebar in concrete, or have more questions about galvanic corrosion, please contact the AGA technical department at 720-554-0900 x21.

**CORRODED
END**
Anodic or
less noble

- Magnesium
- Zinc
- Aluminum
- Cadmium
- Steel
- Lead
- Tin
- Nickel
- Brass
- Bronzes
- Copper
- Nickel-Copper
Alloys
- Stainless Steels
(passive)
- Silver
- Gold
- Platinum

Cathodic or
most noble
**PROTECTED
END**

Figure 2