Technical Bulletin

Dissimilar Metals

What are dissimilar metals?

All different metals are dissimilar with respect to one another, but the degree of dissimilarity varies even between two types of steel. A system has been developed for ranking dissimilarity of metals according to their corrosion behavior in given environments. This rating system is known as the Galvanic Series. The Galvanic Series for seawater is often used to rank metals common to building construction because it provides a good model of corrosion behavior of metals in many other corrosive environments, such as those encountered by buildings.

The Galvanic Series measures a metal's tendency to react with other metals in a certain environment. The metals are divided into groups according to their behavior patterns. The closer two metals are in their ranking, the smaller is the chance that they will react with one another. Thus two metals in the same general grouping are considered to be compatible. Also, the farther apart two metals are in their ranking, the greater is their dissimilarity, and the greater the potential for galvanic corrosion if they are used together.

Galvanic Corrosion

Galvanic corrosion is defined as "A form of electrochemical corrosion that occurs when two dissimilar metals come together in the presence of an electrolyte to form a couple, known as a galvanic couple." In the building industry, the electrolyte is usually water, present in the form of liquid or vapor (rainwater or atmospheric humidity). When a galvanic couple is created, an electron transfer begins to occur.

The direction and rate of this transfer will depend on where the metals are within the Galvanic Series. Remember that the further apart they are, the greater the potential for corrosion. This process causes the more reactive metal (known as the anode) to give up its electrons to the less reactive metal (known as the cathode) and thus corrode. The cathode will begin to corrode according to its position in the Galvanic Series, but not until the anode is completely corroded. In the case of galvanized steel, steel is plated with or dipped in molten zinc, and this process is driven by galvanic couples. Plating results in a zinc coating on the steel, whereas with hot-dipping the zinc diffuses partway into the steel. If the zinc coating is penetrated, by a scratch or other mechanical means, the zinc and steel will form a galvanic couple; the zinc acting as the anode. Initially, the zinc will give up electrons and corrode until it is nearly all gone. Then, of course, the steel will begin to corrode.

Effect of Area

One of the determining factors of corrosion rate of a galvanic couple is the relative area of the cathode. For example, a steel fastener in an aluminum sheet will act as the anode due to the relative behaviors of steel and aluminum in the Galvanic Series. However, due to the disparity between the tiny area of the fastener and the tremendous area of the aluminum sheet, the fastener will surrender its electrons at a greatly accelerated rate. This phenomenon is known as the area effect. If the roles are reversed, and an aluminum fastener penetrates a steel sheet, the steel will still corrode, but at a greatly reduced rate due to the tributary area of the steel. Consider this illustration of the area effect: the use of a steel pop-rivet in an aluminum gutter.

The steel rivet would very likely be completely corroded in three months. On the other hand, an aluminum pop-rivet in a steel gutter would last much longer. The steel would still be the anode, and would eventually corrode, but at a much slower rate.

Effect of Temperature

Temperature is also a determining factor of corrosion rate of galvanic couples. When considering the behaviors of steel and zinc according to the Galvanic Series for seawater, zinc is known to be anodic to iron and steel at temperatures below 140 F. But above 140 F, iron is anodic to zinc. This can have an impact on roofing products which can easily reach surface temperatures of 180 F during normal service conditions. The temperature effect is one reason that galvanized roofing products do not perform well in saltwater environments.

Prevention of Galvanic Corrosion

Galvanic or dissimilar metals corrosion will occur to some degree with any combination of metals. All metals will eventually tend to corrode, but proper selection and application will provide the longest service life possible. Recall that three things must be present in order to set up a galvanic couple:

1. Dissimilar metals in electrical contact
2. The degree of the dissimilarity will govern the corrosion rate
3. An electrolyte must be present

If even one of these is eliminated, it will preclude the possibility of the formation of the couple. This leads to the following options for prevention of galvanic corrosion:

Removing the moisture in the air (neither practical nor possible in most applications) using similar metals proximately located in the Galvanic Series, and creating a barrier to prevent electrical contact between the two metals. A heavy body bituminous paint works well as an electrical barrier to prevent coupling, but proper materials selection is usually the best and simplest means. Alternately, painting the cathode will reduce its effective surface area, thereby reducing the corrosion rate of the anode.

Metal Selection Practices

Roof Sheet Recommended Fastener

Not Recommended

Galvanized/ Galvanized steel Aluminum

Galvalume - 300 series S.S.

400 series S.S.

Aluminum/ Aluminum Galvanized Steel

300 series S.S. Copper

Copper/ Copper Galvanized steel

300 series S.S. Aluminum

In General: flashing and trim should be the same material as the sheets. If roofing material is different from siding (Aluminum roof & steel siding), use heavy body bituminous paint or sealant tape to separate the dissimilar metals at their contact point.