Discussing dissimilar metals

Roof system designers must consider minimizing corrosion potential among dissimilar metals

by Mark S. Graham

When two dissimilar metals come in contact, such as when metal fasteners are used to attach metal flashings or accessories, one of the metals has an increased potential to corrode. This is referred to as galvanic corrosion, and there are steps roof system designers can take to prevent this from occurring.

Galvanic corrosion

When two dissimilar metals come in contact and are exposed to a common electrolyte, one of the metals can undergo increased corrosion while the other metal can show decreased corrosion potential. Any solution containing water can be an electrolyte. Rainwater, dew and condensation are electrolytes because they contain dissolved ions from common environmental conditions. In comparison, seawater is a more conductive electrolyte and, therefore, more corrosive because of its much higher concentration of dissolved salt ions.

Because galvanic corrosion can occur at a high rate, it is important a reliable means be used to identify dissimilar metal combinations that exhibit galvanic corrosion potential.

A method commonly used to predict the effects of galvanic corrosion is to develop a galvanic series by arranging a list of metals in order of

ACTIVE END (-)

- Magnesium
- Magnesium Alloys
- Zinc
- Galvanized Steel
- Aluminum 1100
- Aluminum 6053
- Alclad
- Cadmium
- Aluminum 2024 (4.5 Cu, 1.5 Mg, 0.6 Mn)
- Mild Steel
- Wrought Iron
- Cast Iron
- 13% Chromium Stainless Steel Type 410 (active)
- 18-8 Stainless Steel Type 304 (active)
- 18-12-3 Stainless Steel Type 316 (active)
- Lead-Tin Solders
- Lead
- Tin
- Muntz Metal
- Manganese Bronze
- Naval Brass
- Nickel (active)
- 76 Ni-16 Cr-7 Fe Alloy (active)
- 60 Ni-30 Mo-6 Fe-1 Mn
- Yellow Brass
- Admirality Brass
- Aluminum Brass
- Red Brass
- Copper
- Silicon Bronze
- 70:30 Cupro Nickel
- G-Bronze
- M-Bronze
- Silver Solder
- Nickel (passive)
- 76 Ni-16 Cr-7 Fe Alloy (passive)
- 67 Ni-33 Cu Alloy (Monel)
- 13% Chromium Stainless Steel Type 410 (passive)
- Titanium
- 18-8 Stainless Steel Type 304 (passive)
- 18-12-3 Stainless Steel Type 316 (passive)
- Silver
- Graphite
- Gold
- Platinum

NOBLE OR PASSIVE END (+)

Figure 1: Galvanic series of various metals

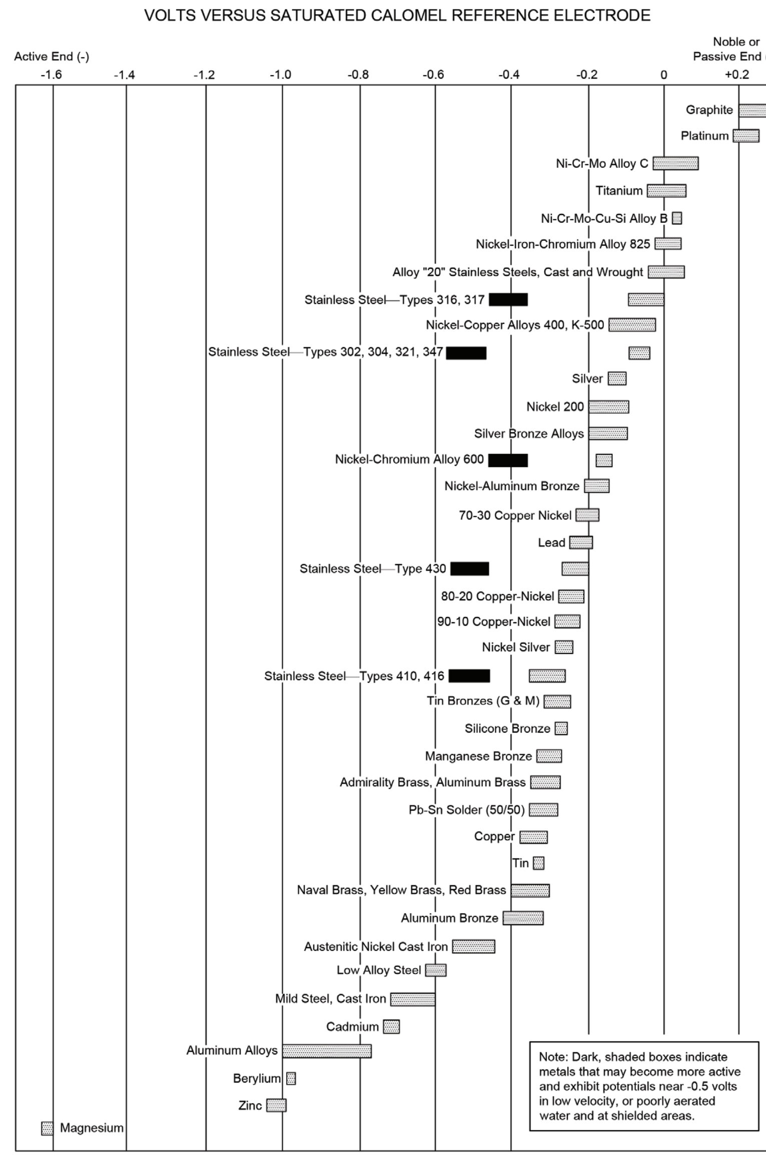

Figure 2: Galvanic series of various metals (adapted from a similar table in ASTM G82)

observed corrosion potentials. One such galvanic series based on metals exposed to seawater is shown in Figure 1. This galvanic series is formatted with the most active (electronegative) metals at the top and the most noble, or passive, (electropositive) metals at the bottom.

A more complex galvanic series is provided in Figure 2. This series acknowledges most metals have ranges of potentials based on their specific compositions, which are depicted in this series using bars. Some metals, such as tin, have relatively narrow potential ranges, while other metals, such as aluminum alloys, have notably wider potential ranges. This galvanic series is presented with the most active metals on the left and most noble, or passive, metals on the right.

Generally, the more active metal (anode) tends to undergo increased corrosion while the more noble, or passive, metal (cathode) tends to undergo reduced corrosion.

Usually, the farther apart two metals are in a galvanic series, the greater the driving force for galvanic corrosion becomes.

NRCA recommendations

NRCA recommends roof system designers consider galvanic corrosion and consult a galvanic series for the specific metals being considered when dissimilar metals will be involved on a project.

Also, designers should consider local environment, the metals' anode to cathode area ratio and runoff from incompatible metals. For example, 300-series stainless-steel fasteners are successfully used with galvanized sheet metal though stainless steel is far removed from zinc in the galvanic series. However, the reverse presents a problem because it combines a small anode with a large cathode.

Similarly, water runoff from a copper gutter into an aluminum downspout will result in premature failure of the aluminum downspout. On the other hand, an aluminum gutter draining into a copper downspout would not have the same effect (except at the connection point of the two metals).

Additional information about dissimilar metal contact and considerations about how to minimize corrosion potential is provided in Chapter 1—Guidelines Applicable to Metal of the Architectural Metal Flashing section of *The NRCA Roofing Manual: Architectural Metal Flashing and Condensation and Air Leakage Control—2018.*

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App can help identify construction design hazards

Researchers at Glasgow Caledonian University in Scotland have introduced a multimedia app capable of identifying construction hazards, according to www.constructiondive.com. Intended to assist architects and designers, the app uses video and images to identify hazards related to building design elements.

> “Researchers believe the app can be used to improve the health and safety of construction workers”

A team of researchers led by Glasgow Caledonian University Prof. Billy Hare selected 40 designers to test the app. The experienced and novice architects and engineers were instructed to review a set of computer-aided design drawings, with half the participants looking for potential design-related hazards using the app and the other half using the internet. Participants who used the app identified 599 hazards—three to five times more incidences than participants who used the internet. Following the successful test, researchers believe the app can be used to improve the health and safety of construction workers, as well as future occupants and building users. They now are looking for developers to help produce a prototype digital app that can be rolled out to the construction industry.

To view a list of six apps that help identify work-site hazards, go to www.professionalroofing.net.

Michigan team demonstrates shingle-nailing drone

A team at the University of Michigan, Ann Arbor, has demonstrated an octocopter capable of attaching asphalt shingles to roofs with a nail gun, according to news.umich.edu. The autonomous aerial vehicle positions the nail gun on a nailing point, places the nail and moves to the next point without needing a human at the controls.

“For me, the biggest excitement of this work is in recognizing that autonomous, useful, physical interaction and construction tasks are possible with drones,” says Ella Atkins, a professor of aerospace engineering and robotics.

Drones currently can address tasks that pose fall risks by inspecting bridges, wind turbines and cell towers. Atkins says the natural next step is to upgrade from surveillance alone to performing physical tasks.

Atkins' team used a system of markers and stationary cameras to enable the octocopter to precisely locate itself in space. They used this system to tell the octocopter where the nails should go. To fire the nail gun, they first measured the force needed to compress the point of the nail gun, which must be done before a nail will deploy. They then wrote software that would allow the octocopter to apply that force.

The off-the-shelf version of the electric nail gun requires a trigger to be compressed, as well, but the team turned that into a virtual switch that activated when the octocopter was in position to place a nail.

For now, the drone is slow compared with humans performing roofing work.

“Initially, we tried using faster approach speeds to minimize nailing time,” says Matthew Romano, a robotics Ph.D. student. “However, for those attempts, the nail gun tip often bounced off the roof, which meant it either wouldn't trigger or it would trigger in the wrong place.”

In addition to speed, the team identified other needed improvements. For example, the drone should be powered by tether rather than battery, which would allow it to run indefinitely. Additionally, an air line running alongside the power cable could make the nail gun a more effective pneumatic model.

A paper regarding the team's work, “Nailed it: Autonomous roofing with a nailgun-equipped octocopter,” was submitted to the International Conference on Robotics and Automation. The study was funded by the National Science Foundation.