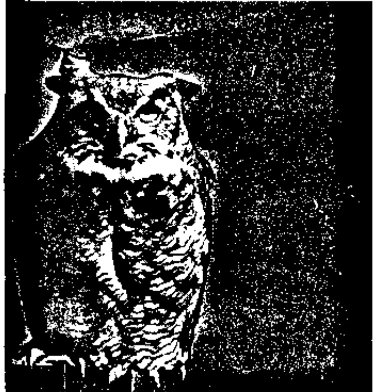

The Technical Corner

GALVANIC CORROSION

Electrolytic corrosion, sometimes called electrolysis, and galvanic corrosion, often referred to as two-metal or dissimilar metal corrosion, are somewhat similar in nature, but result from different causes. Electrolytic corrosion results from the action of an imposed direct current. Galvanic corrosion results from self-induced currents which in turn have resulted from the electrical potential between two dissimilar metals in contact.

As applied to piping or structural installations in which copper is a part, electrolytic corrosion from stray currents can almost be disregarded. The passing of the street railway, with its high amperage direct current, has virtually eliminated the stray-current possibility. It has sometimes been thought that grounding telephone or electric power wires might cause electrolytic corrosion, but several investigations have disproved this theory.

For galvanic corrosion to occur, two dissimilar metals must be connected in the presence of an electrolyte. Salt water and acid solutions are excellent electrolytes. Ordinary fresh potable water is a weak electrolyte, and distilled water or condensate, extremely weak electrolytes. Steam will not act as an electrolyte at all. The weaker the electrolyte, the more limited the galvanic action. It should be emphasized that with fresh water, galvanic corrosion is not common. Often, any form of corrosion not clearly understood is wrongly labeled electrolysis, electrolytic action, or galvanic corrosion. To aid study of the problem, the various metals have been listed in what is known as the galvanic series. One end of the series is "most noble," the other, "least noble." The least noble end includes metals that are anodic toward those further up the scale. This means they are corroded because, when joined to metals higher in the scale, they are electro-negative. The self-generated current leaves the less noble or anodic metal to enter the electrolyte and it carries the metal with it.

Metals nearer the more noble end are cathodic and electropositive with respect to the less noble metals with which they may be joined. This protects them from corrosion. Current enters the metal from the electrolyte and may deposit on the cathodic metal the metal it has corroded from the anodic metal.

More commonly, however, the corroded metal deposits out of the solution as a compound mixed with minerals from the water. The cathodic metal also is protected by its positive potential.

The galvanic series table is below. It lists only those metals usually used for piping (those within a group are essentially equal):

CORRODED, ANODIC OR LEAST NOBLE END

ZINC
GALVANIZED STEEL OR IRON

ALUMINUM

STEEL
IRON
CAST IRON

LEAD
TIN

BRASSES
COPPER
BRONZES
COPPER METAL ALLOYS
MONEL

PROTECTED, CATHODIC OR MOST NOBLE END

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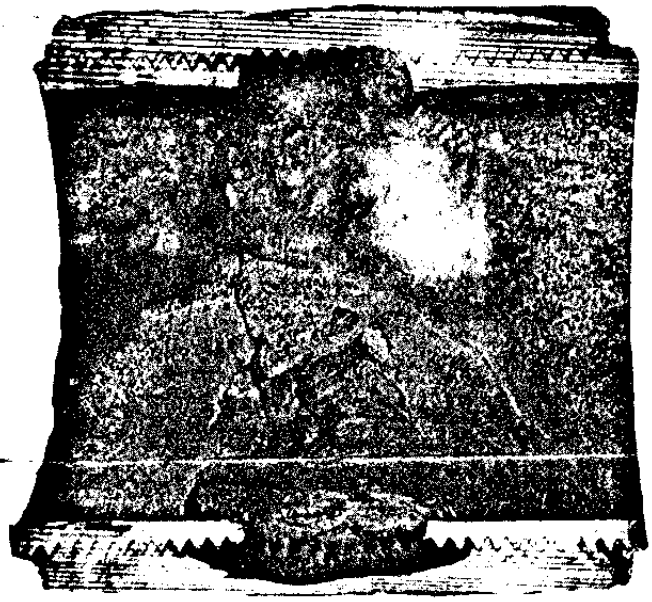
Although not proportionate, the further the metals are apart in the series, the greater the difference in electrical potential and the greater the possibility of galvanic corrosion (if it occurs at all). Thus, copper is usually the galvanically protected metal when connected to other commercial metals in a piping system.

For example, suppose copper water tube is to be connected to a steel pipe by means of an adaptor and the water in the system is an electrolyte. The steel, being electro-negative to the copper, will corrode. The current-carrying metal will enter the water at the steel surface and then flow into the copper. Since the electrolyte has a large electrical resistance compared to the metals, most of the current and galvanic action will be confined to the area close to the metal-to-metal-contact. Little galvanic action will occur beyond 6 inches from the contact. It may be accepted that corrosion attack remote from the joint has been caused by some other factor than galvanic effects.

This discussion has covered the fundamentals of galvanic corrosion and to some extent has oversimplified the problem. By considering only the fundamentals, it can better be understood why the conditions for galvanic corrosion appear to exist, but why the phenomenon seldom actually occurs. There are thousands of combinations of metals in contact under conditions where galvanic corrosion might occur: washing machines, boats, air-conditioning equipment, hardware, plumbing equipment, autos and buses, railroad cars and structures of all kinds. Rarely, however, is an authenticated case of galvanic attack found severe enough to be troublesome. There are several possible reasons for this. Most important is that the electrolyte is seldom strong enough to promote the action. Also, the differences of potential assumed in the galvanic series are for salt water as an electrolyte, and other electrolytes may be and generally are productive of considerably lower potentials. The metals may form protective films which act as insulators, or, at least, partial insulators. Also, relative size of the metals being joined will affect the amount of galvanic corrosion. A large anode area compared to the cathode area is much safer than when the cathode area is large compared with the anode area. For instance, a steel coupling joining two copper pipes would be bad practice.

As has already been pointed out, when copper tube is connected to some other metal piping material, *if galvanic corrosion occurs,* it is the *other* material that is usually attacked, while the copper is protected. Of course, the obvious way to prevent this is by the use of an all copper system. However, there may be circumstances where this cannot be done, and in such cases it is possible to make the pipe connections so that whatever chance there is of galvanic attack may be largely or entirely eliminated.



Severe corrosion of a malleable iron coupling used to join two lengths of red brass pipe. There is no galvanic attack on the brass, but the iron has been badly corroded and thick iron rust clogs pipe.

For instance, there are available couplings or unions into which a dielectric or insulating material has been built, which theoretically serves to break the electric contact and therefore prevent the galvanic action. Although these devices are quite short, the induced current is rarely strong enough to jump the insulation. A union or coupling with the insulation at least 6 inches long is better than the short coupling if there is any possibility of the current by-passing the insulation. If the current is impressed on the line from outside sources (a condition which rarely exists), it may jump even a long insulation.

Where dissimilar metals must be connected and where experience has indicated the probability of galvanic attack, and where the joint is readily accessible, a suggested procedure is to use two couplings about a foot or so apart, connected to each other by a pipe of the less noble metal. One of the unions, the one which now connects the dissimilar metals may be of the dielectric type, the other may be of an ordinary union. This short section of pipe constitutes a "suicide" section in which all the attack will be concentrated. By having a spare section handy in case of need, a replacement can be quickly and easily made.

To sum up, when a copper or brass tube or pipe must be connected to a pipe of some other material, experience has shown that galvanic corrosion seldom occurs, but when it does, it is the other metal that ordinarily is attacked, within a narrowly limited area. Any attack not meeting these conditions is some other form of corrosion, not galvanic corrosion.

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