Electrical Connection: What You Can Do to Prevent Corrosion

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There are two general types of corrosion that are of concern in electrical connections: oxidation and galvanic. Oxidation and galvanic corrosion affect both the initial contact and the long–term performance of an electrical connection.

Oxidation Corrosion

Oxidation can develop on the connector as well as the conductor to be joined. Copper oxide forms on the copper surfaces and is low in conductivity. Evidence of copper oxide can be seen as a black or green surface discoloration. Copper oxide layers will reduce the number of contact points in a connection, thus increasing the contact resistance. Therefore, conductors should be cleaned prior to making a connection.

Aluminum oxide is a fast forming, hard, non-conductive coating that develops on the surface of aluminum conductors exposed to air. Unlike copper oxides, aluminum oxide is not visually obvious and should be assumed to exist in all cases of bare aluminum. Aluminum oxide must be removed from a conductor's surface prior to making a connection. Wire brushing and the immediate application of an oxide inhibitor are recommended to prevent the reformation of the non-conductive coating prior to connector installation. An alternate method that is used to achieve low contact resistance is for the connection methodology to physically break through the aluminum oxide layer as the connection is being made. Even with these types of connections, however, cleaning the conductor is still recommended prior to installation.

An additional problem with aluminum cable is the oxide layers that develop on each inner strand. These layers can cause high inner-strand resistance and are not easily removed. This problem is accentuated in compact conductors due to the restricted movement of cable strands when force is applied during connector installation. In these cases, the use of a contact aid with particle additives helps in breaking through inner-strand oxidation layers and in establishing the required contact spots.

Galvanic Corrosion

A major cause of long-term deterioration in an electrical connection is galvanic corrosion. Aluminum and copper conductors are commonly used in the electrical industry. This use of dissimilar metals can lead to problems of galvanic corrosion if preventative action is not taken. Aluminum becomes the anode in the galvanic cell that is formed when in contact with copper, and is therefore the material that undergoes the corrosion.

Whenever dissimilar metals are in the presence of an electrolyte (i.e. moisture), a difference in electric potential develops. One metal becomes the cathode and receives a positive charge. The other becomes the anode and receives a negative charge. When these metals are in contact with an electrical current with flow, as in the case of any short-circuited electric cell, this electrolytic action causes an "attack" on the anodic metal, leaving the cathodic metal unharmed. The extent of the attack is proportional to the strength of the electrolytic current, which in turn is proportional to the electric potential difference developed.

The magnitude of the potential difference generated between two dissimilar metals can be seen by the position of these metals in the electrolytic series **(refer to FIG.1)**. When two metals are in contact in an electrolyte, the one higher up in this series is the anode, the corroded metal, while the lower one is the cathode, the protected metal. The further apart the metals are in this series, the greater the electrolytic potential difference, and the greater the attack to the anodic metal.

Note that copper and aluminum are quite far apart in the series, copper being cathodic and aluminum anodic. Hence, when aluminum and copper are in contact in an electrolyte, the aluminum can be expected to be severely attacked.

Tin Plating- National Electrical Code Construction

Most connectors used in code-construction are tin-plated. Copper connectors for code-construction are tin-plated to prevent them from discoloring, a common occurrence with bare copper. Whereas, aluminum connectors for code construction are tin-plated to lower their contact resistance. Electrical connectors are tin-plated for three basic reasons:

1. To improve their appearance
2. To lower contact resistance
3. To eliminate galvanic corrosion

Connectors that are UL listed for use on aluminum and copper conductors are generally fabricated of aluminum. Therefore, in order to meet the test requirements of UL486B, the test samples must be installed entirely without special preparation of the connector contact surfaces and without the addition of connector compound. Electro-tin plating these aluminum connectors is an efficient and economical way of satisfying the UL486B test requirements.

Tin Plating- Outdoor Construction

Where there is no concern about galvanic corrosion, most connectors of outdoor construction are supplied unplated. Bare copper and the copper alloys from which connectors are made are nearly impervious to damage from the elements, and the same may be said of aluminum. Outdoor connections between aluminum components must be made with care, including abrading the surfaces to remove the oxide film and using a connector compound on contact surfaces.

The addition of tin-plating does not improve the prospects for a long-lived connection in either all-copper or all-aluminum connections. Where copper and aluminum components must be joined, however, tin-plating may be called for, in particular to protect an aluminum conductor (aluminum cable or aluminum bus) from galvanic attack.

Cleaning and the Use of Compound

It should be emphasized that when aluminum connectors or conductors are involved, proper cleaning of the aluminum and the use of a good oxide-inhibiting compound, such as BURNDY® PENETROX A™, is essential for trouble-free service. Connector compounds assist in providing the contact grooves necessary for a sound electrical

connection, but in all cases, the aluminum conductor should be cleaned by means such as scratch brushing and immediately coated with the connector compound.

To simplify the application of the compound, and to assure its use, many aluminum connectors, except the large clamp type substation connectors, are supplied factory-filled with compounds. For the tubular compression connectors, the tubular barrels are sufficiently filled with connector compound and capped.