Tel. 800-269-1462 Fax. 800-311-9857
382 Park Ave East, Mansfield, OH 44905
www.ClassicConnectors.com
Classic Connectors USA, LLC

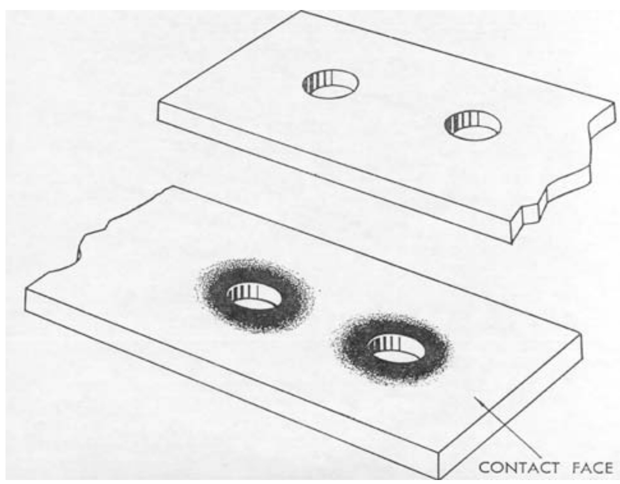
Choosing the Right Fasteners - Part II

By Carl R. Tamm

In the first part of this article, a brief mention was made regarding “conductivity” of fasteners. This second section will address that issue.

Peculiarities of electrical connectors give rise to further thought of fasteners. It is not exceptionally difficult, using reasonable workmanship and materials, to make an electrical connection of reasonable conductivity initially – however, to make one which will provide exceptional duration for many decades is another story.

While there are many types of “bolted connectors” used in the utility industry, for simplicity references this article will relate to flat “pad-to-pad” type connections. The physics involved in the atomic structure of the electrical interface are too involved to address in this article, however sufficient evidence is readily available to show that a typical 4-bolt pad-to-pad connection will achieve less than 2% of the “available” surface area that will actually make an electrical connection. Some of the earlier references to this phenomenon of area immediately surrounding the bolt holes being the only actual contact area date back over 55 years.



Kaiser Aluminum – Electrical Bus Conductors, 1957

Accepting this long stated peculiarity to be true, one might ask, “What could be done to improve that value?” The industry has been striving to improve the area of contact “between” the pads – but the obvious option of allowing the bolts to serve as conductive paths is often overlooked.

Use of conductive washers and fasteners can provide additional current paths from the backside of the respective pads, through the fasteners! How obvious is that? Why do so many disregard this simplistic improvement? Some other misunderstandings, such as reusing fasteners, will be addressed in a future part of this article.

Perhaps a simplistic understanding of fastener conductivity will help. One may look at either conductivity or resistivity. I prefer the former, as the numbers are more simplistic and easy to understand. The common basis used for conductivity values is the International Annealed Copper Standard, abbreviated IACS. The following chart indicates values for a number of materials commonly used in our industry, and a few more for reference.

International Annealed Copper Standard

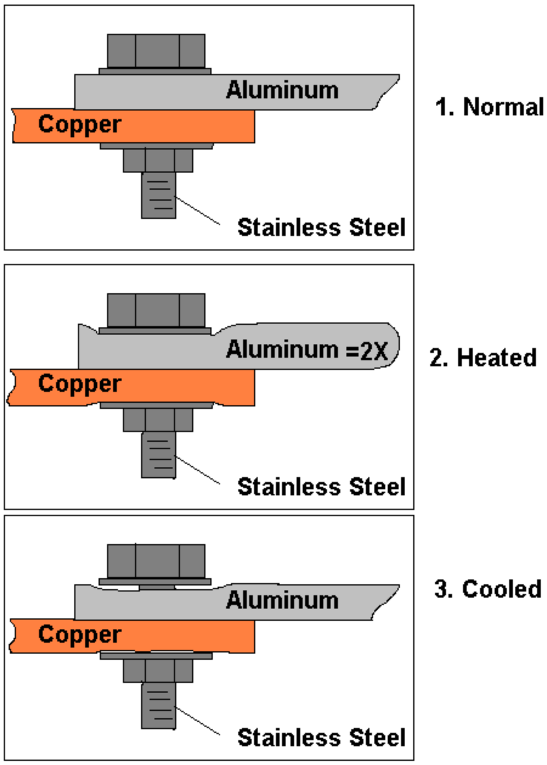
Pure Annealed Copper	Cu	100%
Tough Pitch – Electrolytic Copper	Cu	101%
Pure Annealed Aluminum	Al	64%
Silver	Ag	105%
Gold	Au	73%
Platinum	Pt	16%
6061-T6 Aluminum Alloy	Al	42%
1350-H19 Aluminum Alloy	Al	61%
Iron / Steel	Fe	2.5%

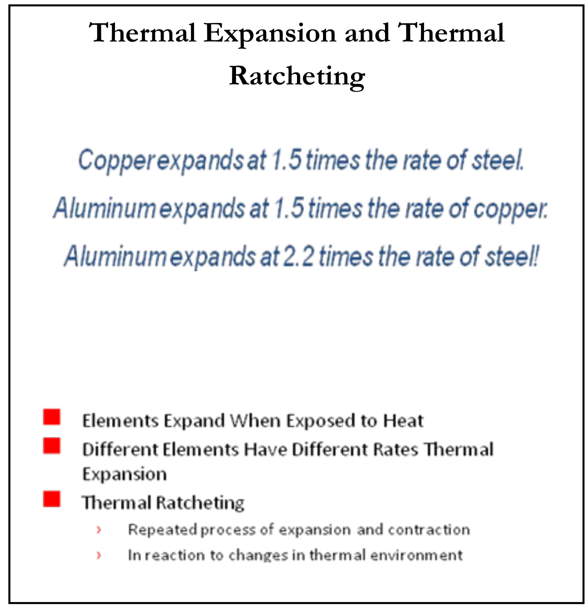
Most are surprised to learn that Gold is not the most conductive material, but is significantly superseded by Silver! The attributes of gold, and its place in Contact Physics is not the subject of this article. Of equal surprise to most, is that while we all recognize iron and steel are conductive, its value of conductivity is only 2.5% IACS. This value is close enough for argument, not to get into the specific values of different alloys, and represents all common ferrous alloys, and includes “stainless” alloys.

Alloys used for connectors commonly range from 16% to about 44%. While Silicon Bronze bolts, or the common aluminum alloys used for bolts are not nearly as conductive as the materials used for conductors, they commonly do approach the conductivity of many connectors, of approximately 16% to 24%. The lesser degree of conductivity of these fasteners is due to the alloying elements used to provide the strength needed for fasteners. Still, these conductive fasteners provide 8 to 12 times the conductivity of steel.

What is the result of using steel or stainless steel bolts in connectors? While very low in conductivity, they are yet conductive, and the low value of conductivity is the reason for the “high resistance” associated with steel. The very definition of resistance is associated with the thermal rise of the material as the result of passing electrical energy through it. The physical effect is the expansion of the material due to the thermal rise. With bolts, the higher the temperature, the less clamping force provided!

To counteract this, properly designed and applied Belleville washers are used to maintain the clamping force, as Mr. Goch covered in Part 1 of this series. As Part 2 began, our purpose is to provide a bolted joint that will maintain the electrical integrity of the connection over many decades. Maintaining the clamping force is paramount to achieving this goal. The following illustration depicts the effects of the difference in the coefficient of thermal expansion between differing materials used in electrical connections.





As the illustration depicts, differing materials expand at differing rates over a given temperature rise. This property is given stated values for different materials, known as the coefficient of thermal expansion related to the respective materials. Both aluminum and copper alloys expand at a greater rate than steel. The use of steel bolts, without the benefit of properly sized and applied Belleville washers will result in rapid creep of softer material of the connectors, and the joint will loosen over time. Of course, as it loosens, the resistance will rise, and with that given rise in resistance, the thermal rise for a given current will increase.

There exist several design features incorporated in ClampStar, the result of which provide a superior connection to other types of connections, including compression connectors. Thus another reason ClampStar provides the properly engineered Belleville washers in its fastening system! As Mr. Goch stated in the previous part 1, the torque nuts, designed by Classic Connectors, Inc., prevent over-tightening of the fasteners, and thereby prevent over compression of the Belleville washers.

Additional information on Belleville washers will be incorporated in another series!