

## Cable and Connector Longevity

This article was kindly donated by George Cardas

I receive a lot of questions about cable longevity. In general, most standard cables will function for years without catastrophic failure. These cables begin to break down in the same amount of time it takes for your new car to start having electrical problems. Specialty type cables, properly designed, can last for decades without attention. Signal degradation due to cable connection problems, however, occurs in a much shorter time. These problems are related to the metals used in and on the conductors and connectors.

Problems occurring in properly maintained electronic equipment often trace to wire connections and solder joints. Much of what we know about these problems can be applied to both cable and circuit boards interchangeably. Corrosion is the primary problem. The surface of conductors, connectors, board traces, etc. is prone to corrosion. Dig some old equipment out of the junk pile, you will see the traces, solder joints and conductors are coated with the corrosion that likely sent them there. Higher quality boards are now coated with a varnish that prevents surface corrosion, as are the conductors in high end cables. Bi-metal junctions can greatly accelerate corrosion. In the late 60's Western Electric discovered a way to solve this problem. It is called 63-37, Tin-Lead, eutectic solder. Eutectic solder is a unique combination of metals with a melting and solidification point lower than any of its component parts. It joins similar materials into a continuous joint, rather than a bi-metal junction. 63-37 solved the problem in circuit boards with Tin conductors and all boards are now soldered with it. Cable is more complex, because you are joining Copper and Silver. So in 1988 I developed Tin-Lead-Silver-Copper eutectic solder, or Quadeutectic Solder, that is now used in most high end cables and equipment.

Unfortunately we can't solder everything and connectors are a must. The main problem with connectors is erosion from the current flowing through the connection. The plating materials will largely determine the quality and life of the connection. A big failing in tube equipment is the tube pins. Pin metal is selected for its compatibility with glass, with little concern for its ability to connect. You periodically have to wiggle the tubes to avoid degradation of the sound, eventual noise and final failure of the circuit. Cable to board connections are similar and the need to wiggle is very familiar.

Gold is a common plating choice because it does not corrode, but it is far from a cure for erosion. Gold is soft and the surface is not molecularly flat, which is why it has color. So current fluctuates, causes erosion (the black grunge on used Gold connections is eroded Gold dust) and the eventual need to wiggle.

Erosion is proportional to current fluctuation. The higher the current and the more it fluctuates the faster the connection deteriorates. Contact failure in early microwave and radar equipment caused the military's quest for better plating. The best plating material is a metal called Rhodium. It is extremely hard and flat, it does not corrode or erode, but it is very expensive. So the military's solution was not a solution everyone could afford. Today, only the best cables use rhodium plating, but special direct plated, Hard Gold formulations (like on the Audioquest connectors and I believe XLO) have also found success. There is also a Palladium alloy that is almost as good as Rhodium. Unfortunately many cables are sold with Nickel plating or Nickel with a soft Gold flash for color. Nickel is magnetic and a poor choice by comparison to hard Gold, Palladium or Rhodium.

Metal purity also effects cable longevity. Impure metals eventually "work-harden". In large cables, such as power lines, the life is 30 years or more. In small conductors, life is much shorter, especially near connections where the material has been mechanically worked or sharply heated and cooled such as welded or crimped joints.

The bottom line: Enamelled pure copper or silver joined with low temperature eutectic solder, annealed and properly potted is pretty much forever. Properly made and plated connectors will last for decades in normal use.