Crimps

In 1941a New Jersey company had a faster, less expensive, and more reliable way to attach wires to terminals for the aircraft and shipbuilding industries. Before World War II, wires were connected by twisting their ends together or wrapping them around screws or soldering them to small metal posts that served as terminals. The company, named Aircraft-Marine Products Inc. (AMP). The product, a crimping tool that looked like a pair of pliers, squeezed the terminal onto the wire, binding the two in a snap that set off a manufacturing revolution in the electronics industry.

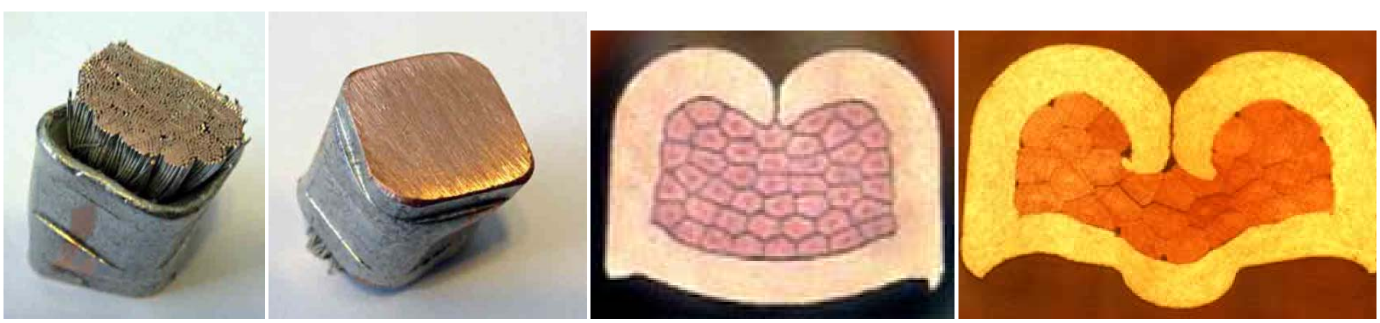
Gas-Tight Connections

Crimping technologies enabled far more rapid and consistent wire terminations compared to soldering. Over the years many different methods of crimping technology were invented for single wires, multiple wires and coaxial cables. While most people assume a "crimp" is just a contact crushed onto a wire, giving electrical conductivity by means of pressure, real crimping involves "elastic" and "plastic" deformation and flow of metals resulting in "micro cold welds" due to contact asperity welding (*the elastically compressed region of contact between two surfaces*) of the metal surfaces. During the deformation process the wire and connector are mechanically cleaned. When done right, this crimped connection can be much stronger and longer lasting and have electrical resistance of the equivalent length of wire. A properly done crimp is also gas-tight as well, not allowing oxidation to degrade it over time.

Gas-tight means sealed against the possible penetration of air molecules, as well as airborne contaminants. Metal-to-metal gas-tight connections are those where oxides or other surface contaminants are absent or removed, if necessary, by mechanical or chemical means. The enemies of electrical continuity are purely physical. Chemical corrosion is the most insidious, because it doesn't appear until some time after the connections are made.

Creating a gas-tight bond is the first step. The second step is surrounding the exposed metal with enough protection to keep the environment from causing enough corrosion to damage the current path.

Many excellent sealants and techniques are available to prevent or delay leakage of corrosive gases. This involves seals or enclosures or “goops,” but underneath it all there must be a gas-tight bond between the wire and its termination.



Making Sound Connections

Even the lowly screw terminal (on a household light switch, for example) is capable of an excellent gas-tight connection. Assuming things are clean, the pressure and scuffing of the screw-head on bare wire penetrate surface oxides of both and make a good, low-resistance connection.

There are many ways to terminate a wire: soldering; crimping; under the head of a terminal strip screw; welding, all can be successful in forming a good, gas-tight connection. While each has its place, they all require low resistance connection. This means the conductors must be clean at the point of contact, clean enough to put pure metal in intimate, permanent contact with pure metal. Oils, water, rust, corrosion, scale, dirt

— in short, everything that can be reasonably removed should be by wiping with a solvent or, in some cases, scrubbing or abrading the surface. One of the benefits of the crimping process is the breaking-up of surface oxides by the sheer force of deformation.

How to make Good Crimps

There are certain critical factors in crimping that are necessary to create a proper cold welded crimp. The first thing to understand is that all connectors are made to work with a somewhat small range of wire sizes and properly sized terminal. A terminal with too large an internal diameter will not form correctly around the wire, leaving excessive space to harbor contaminants, and could even fall off (insufficient deforming) or crack (excessive deforming). Too small a terminal invites strand-cutting. Using improperly sized wires and connectors will result in poor electrical performance, poor mechanical strength and often a poor or non existent cold welding of materials. Besides matching the connector with the wire or cable, the proper tooling in the proper condition is also absolutely necessary for a proper crimp termination. The wire, the contact and the tooling are all engineered to very exacting degrees. Small amounts of wear or contamination on the crimp dies can result in a poorly formed crimp. Due to the wide variety of crimp types, different methods of field tests are necessary to make sure the proper amount of material displacement is achieved during the crimping process. Some terminals will be crimped and then a "crimp height" will be taken. The crimp height for a terminal will differ with the different wire sizes that the terminal is engineered for. The crimp height is specified by the manufacturer of the terminal and tooling. Manufacturers commonly offer several sizes of a type of terminal to fit different wire conductor sizes. The tooling for these different contact sizes is different as well. the actual "die sets" for different sized contacts are of a unique size and shape by necessity of the contacts design and wire size compatibility.

Crimping

Every terminal is designed for a specific-size wire (or range of sizes) and has a recommended tool, die or tool setting for correct application. **Consistent crimps are performed using only cycling-type tools — those that will not release the terminal until the crimping operation is complete.**

The barrel of a crimp-type terminal fits snugly over the wire and is then deformed, or crushed, using a tool chosen or adjusted to "dent" or deform the barrel to the proper depth and length. Depth of this dent is important to assure that the wire surface(s) and the inside surface of the barrel are in maximum, intimate (gas-tight) contact. The length and location of the crimp must be carefully placed so that only the area surrounding the wire is deformed, not other parts of the terminal. Both depth and length contribute to mechanical strength.

Testing

A "Pull Test" is a very commonly used method of determining the quality of a crimp. It is basically a measurement of how many pounds it takes to "pull" the wire out of the termination. With common wire sizes, this should be as close as possible to the weight necessary to break the wire itself when pulling on it.

Pull force testing is a quick, destructive method to evaluate the mechanical properties of a crimp termination. Pull force testing results out of allowed range are good indicators of problems in the process. Cut or nicked strands in the stripping operation, lack of bell mouth or conductor brush, or incorrect crimp height or tooling will reduce pull force.

If you're within range of the best mechanical strength, you are also within range of the best possible electrical performance. In general, every Manufacturer specifies the proper pull test for various wire sizes.

A very important factor in passing or failing a pull test is where exactly the wire breaks. If the wire breaks within the terminal, it is not usually a good indication. This will usually mean an over crimp, weakening the crimp from too much cross sectional area reduction and "work hardening". If it breaks right where the wire meets the terminal, that may or may not be a bad indication as well. Terminals have what is called a "bell mouth" where the wire enters the terminal. The bell mouth is a flared out area to eliminate cutting into the wires which would happen with an abrupt ending of the crimped area.

When the wire itself breaks outside of the terminal it is generally considered ideal. If the wire is pulled from the terminal without breakage, it is important if it only does so within the rated specifications of the terminal or general crimp specifications.

Wire properties and stranding, and terminal design can increase, or decrease the value of the results of a pull force test. If results of a pull force tests are within an allowed range, it assures that proper crimp force has been applied during crimping. It is crucial as, when making a crimp, enough force must be applied to break down the layer of non-conductive oxides that may build up on the stripped conductor and the tinplating on the inside of the terminal grip. This is necessary to provide a good metal-to-metal contact.

More stuff

Once the correct terminal is selected, proper attachment to the wire is critical. One indication of the importance of proper crimping is evidenced in a study for the Space Shuttle program that traced 28% of all defects to improperly assembled wiring and connectors.

An important and often overlooked feature of most kinds of crimps is the insulation support crimp. This part of the crimp does not contact the wire conductor at all. The Insulation crimp is there to provide strain relief and vibration resistance for the wire crimp. Without a strain relief, or with a poor strain relief crimp, vibration of or repeated flexing of the wires will directly effect the wire barrel crimp and will eventually result in breakage.

Because of speed, cost and repeatability, Crimping is by far the most common type of wire connection used today in electronics. Proper crimping creates a weld between wire and contact, resulting in an extremely reliable, long lasting connection which is extremely resistant to environmental harm.

What crimping tools are in **your** toolbox? Super Champ, NAPA special, ViseGrip, or maybe a hammer and a common screwdriver? A recent memo from the *FAA Continuous Airworthiness Division,* AFS-300, addresses the issue of calibration of crimp tools. The memo says that crimp tools must be capable of being gauged to insure that proper crimp depths are maintained. In other words, they need to be calibrated. This can be accomplished by sending them to a certified lab, the manufacturer, or by the use of a GO/NO-GO gauge. Calibration requirements are normally established by the tool manufacturer.

THESE ARE NOT GOOD CRIMP TOOLS AND SHOULD NOT BE USED

REFERENCES for this paper

Pic Wire and Cable "Making Connections
Ram Electronics "Crimping & Soldering - Keys to Connection Performance and Longevity"
FAA Continuous Airworthiness Division, AFS-300
Molex "Industrial Crimp Quality Handbook"
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