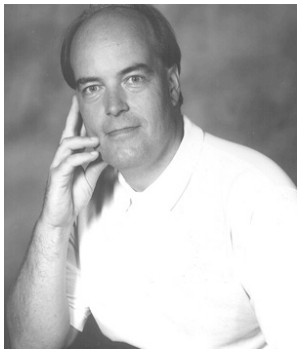
Crimping and Process Control in Manufacture

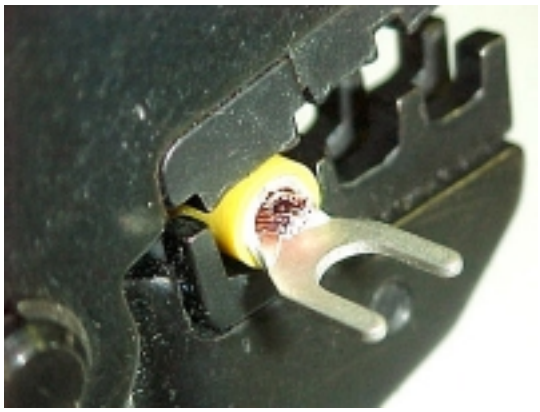


Bob Willis

There are five different ways of producing electrical and mechanical interconnections in the electronics industry. Each can be extremely reliable provided it is correctly produced by training staff and is designed for its intended purpose. The methods of interconnection commonly used are listed below:

Soldering
Wire wrapping
Crimping
Wire bonding
Adhesives

The most common technique for interconnection for single and multi stranded wire is crimping and this process has been used in the market for many years since the original concept was developed by AMP.



Crimping has been around in the industry for many years and has a very good reliability record when connections are designed correctly with the right combination of conductor and termination. Unfortunately the process can often be outside the control of the crimp connector supplier as a connection is not just the connector it is the combination of pin and wire. Provided the two are in the correct combination it them relies on the correct selection of a calibrated tool and trained production staff.

Ask any process or quality engineer about crimping and they will say its simple and not a real problem and it should not be but! Many times crimping is taken for granted, then it all goes horribly wrong. Based on my own practical experience it's when people get complacent or when engineers try to use the incorrect combination of cable and connector. Alternatively it's using the wrong crimp tools or not training staff, hopefully this scenario is not common.

Crimp Tools

There are a wide range of crimp tools and some which are not consider real crimp tools by process engineers. A crimp tool should compress a crimp to the desired size and have the capability to make adjustments for different wire and terminal sizes.

A crimp tool should be capable of some adjustment after calibration by engineering. It should be able to be adjusted due to wear or have its jaws replaced when outside of specification. Finally a professional crimp tool should have a ratchet mechanism which controls the amount of crimping force applied to the crimp and will allow the crimp to be released until full compression has been achieved.

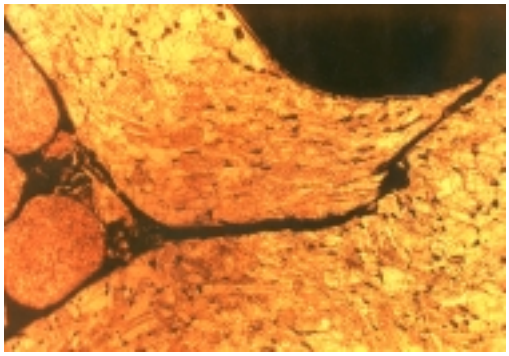
Wire

All crimps are designed for a specific cross sectional area of wire. This gives the capability to use different wire size or number of strands. Using the incorrect cross sectional area will cause either over or under crimping not achieving a gas tight joint. The guidelines from the supplier must always be followed unless engineers are prepared to undertake specific evaluations of the crimp and wire combination.

The following microsections show both under and over crimping and termination cracks. This can lead to mechanical or electrical failures in manufacture or worse in the field.

Microsections

A microsection allows the connector and wire combination to be assessed. It also allows the tool setting to be confirmed for a wire/termination combination which may be outside the crimp terminals specification. It can easily show up under or over crimping as well as cracking of the crimp barrel, lifting of the plating or uneven crimping.



A microsection can be produced in less than a hour if all the materials are available in the company. It can be useful technique if concern is being seen during other tests like pull off or voltage drop measurement. Basically the crimp is mounted in a mould and epoxy resin is used to encapsulate the terminal prior to grinding the sample to the point of interest. This is normally at the point of compression. Ideally the section is ground to the centre of the compressed area and then examined. Which provides the possibility of grinding the section further if there are any areas of concern during initial preparation of the sample.

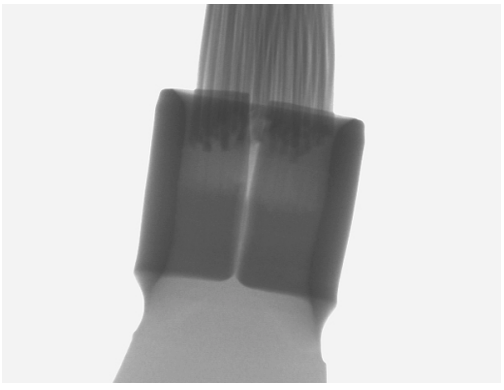
The section should show complete compression with the wire taking up and filling the cavity in the crimp barrel. The tool compression should be even on each side of the crimp and there should be no damage to the plating on the crimp terminal or any evidence of cracking of the barrel. A good well designed crimp combination will show the wire or strands to be compressed and deformed to fill the barrel, any lack of compression will not form a gas tight joint which is the aim of this method of interconnection.

Pull Strength

Pull strength is a simple quick method of test but it is of course destructive. On sample connector wire combinations it is the ideal approach as the equipment required is also relatively simple. In the case of coaxial connections the pull forces are much higher and the equipment more expensive.

As a basic guide the wire should not pull out of the connector and if the wire breaks that is the best that can be expected in terms of joint strength. This is unless a number of wire strands have been inadvertently cut through during wire striping operations, hopefully not a common occurrence in manufacture today.

The use of x-ray is not commonly used to asses crimp terminations but if it's available it can be very quick and eliminate damage to perfectly good products. That was not the case in the samples illustrated here.



Voltage Drop Test

There has been a lot of debate on the value of this test if other procedures and disciplines are in place like pull strength, calibration of tools and certification of staff. The test method has been popular with the Ministry of Defence and more recently with the railway authorities.

Basically sample cable/crimp combinations are tested by applying a voltage to the cable combination. The voltage drop across the connection is measured due to the potential resistance of the compression joint. The equipment can be expensive and must be properly controlled as the voltages used are very high. The health and safety issues must be fully understood by production staff.

Training and Certification

Training is necessary for all staff associated with crimping to provide the highest quality. Training can be very simple and short based on the complexity of the cable and connector design. Operators can also be given the task of assessing their own samples with pull-off force measurement. This proves the complete assembly, material, tooling and process procedure and demonstrates the control in the process.

More complicated two stage connectors should have more detailed training exercises and certification. Two stage connectors may involve soldering or crimping of inner connections prior to crimping braid on coaxial contacts. In these situations the cable strip length, insulation dimension are all critical to avoid intermittent faults. The frequency of training and certification can be debated and reviewed but it should not be eliminated due to zero failures. I have often seen complacency creep in to the whole crimping process, which results in field failures.

Calibration

Tool calibration should be conducted on a regular basis which may be every six months or a year based on system use. If a tool is being used constantly in production the frequency increased. Operator pull off measurements taken at the start of production and during a batch also provides confidence in the tooling.

Calibration should be based on tool usage if a system can be put in place to control the issue of tools. If a tool is not used it can hardly go out of calibration by itself. If tools are issued to production or used for the first time the tool calibration starting date can start from the first time the tool is issued with a job. A simple procedure provided the system is in place to control this issue.

Another method of calibration that is often used on the tooling and is a crimp height measurement. Basically a crimp is produced with the appropriate combination of wire, crimp, tool and die set. The height of the crimp is then measured against information provide by the supplier. These measurements show up and tool wear, correct compression and possibly any damage to the die faces. This can be seen on the surface of the crimp.

As an alternative on some smaller crimps a small length of solder wire can be crimped and the indentations on the surface of the cored wire measured. This avoids the loss of a crimp termination when no contingency of parts has been factored in during purchasing. A contingency of crimps for quality checks and standard calibration should not be forgotten when ordering stock.

For further information on process issues or training staff on any aspect of wire preparation and crimping visit our web site www.bobwillis.co.uk

Bob Willis is a process engineer working in the electronics industry, providing training, consultancy and product failure analysis. He runs production lines for suppliers at exhibitions and also provides seminar and workshops world wide. Bob has one of the largest collection of training videos, interactive CD-ROMs and training material in the industry. Contact him via his web site **www.bobwillis.co.uk** or **www.leadfreesoldering.com**