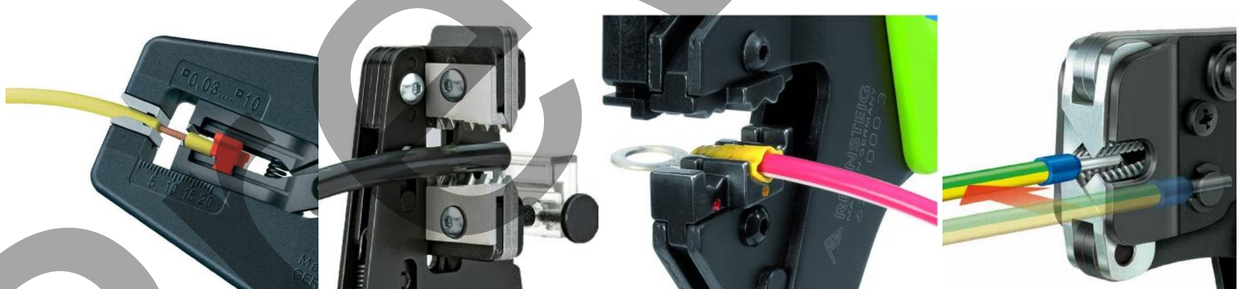
A Preview
To give you an impression of the structure and content of the e-book, we have created this preview for you. For this preview we have selected some pages from different topics.

Hand Tools at Wire Processing & Crimping Technology

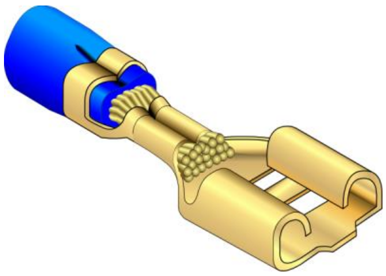
CRIMP ACADEMY
www.crimp-academy.com



- **Handling**
- **Cutting**
- **Stripping**
- **Crimping**
- **Testing**

- **Open crimp barrel**
- **Insulated cable lug**
- **Ferulle**
- **Turned contact**

1. *PREFACE*



Crimp and press connections are an essential component in connection technology. Millions of such connections are made every day. They have largely replaced soldered connections and proven themselves over the years as state-of-the-art connections.

The use of crimp connections can be found wherever electronics or electrics find their application. That is to say, pretty much everywhere.

Particular attention is paid to crimp connections that are integrated into systems that directly serve to protect and ensure the safety of people (like ABS anti-lock braking system, airbag, emergency call systems, aviation, medical equipment, etc.).

However, crimp and press connections are only adequate if they comply with the required standards and can only function if they are well executed.

The challenge in wire processing is the handling of dimensionally unstable materials*. An essential prerequisite for the production of high-quality wire harnesses is first and foremost the experience of the person responsible for adjusting the production equipment as well as the knowledge of the production personnel on what to pay attention to.

This documentation covers the principles of crimp and press connections.

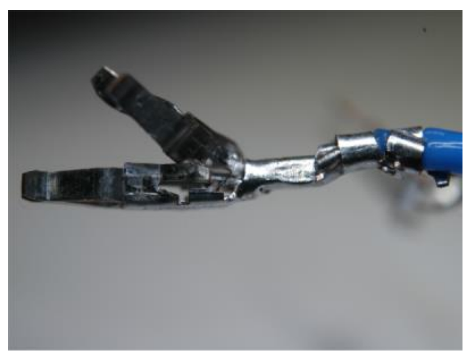
It was created based on current standards and the latest research, always with regard to their relevance in the “real world” of cable harness manufacturing.

This documentation and the seminar film "Principles of crimp and press connections" are intended to give you the opportunity to train and further educate employees within the framework of in-house training courses, or simply to serve as a reference book.

Continuous developments in the field of wire processing mean that this documentation is revised and complemented at irregular intervals. Information on updates or new versions can be found on our websites.

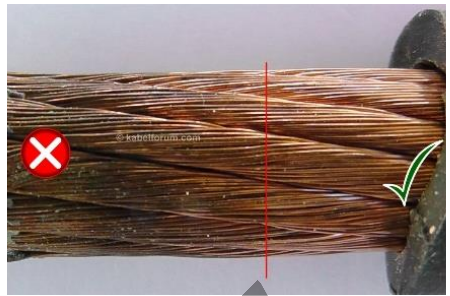
Burned closed end connector

Burned crimp connection



Faulty crimp

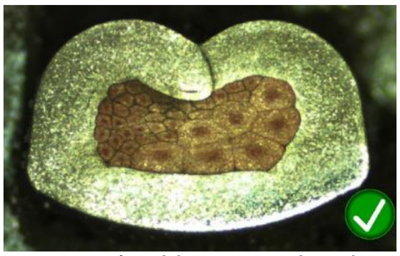
2.4 PROCESSING OF STRANDED COPPER CONDUCTORS



Important: When processing copper strands, good contacting and the lowest possible contact resistance is directly dependent on an optimal crimping process.

Right after the stripping procedure, the process of oxidation begins on the surface of the copper wires. And this affects all individual wires within a stranded wire conductor. Within a very short period of time, a firmly adhering and durable oxide layer of about 2 to 4µm is formed. Depending on the humidity and temperature, this insulating oxide layer is formed more or less quickly.

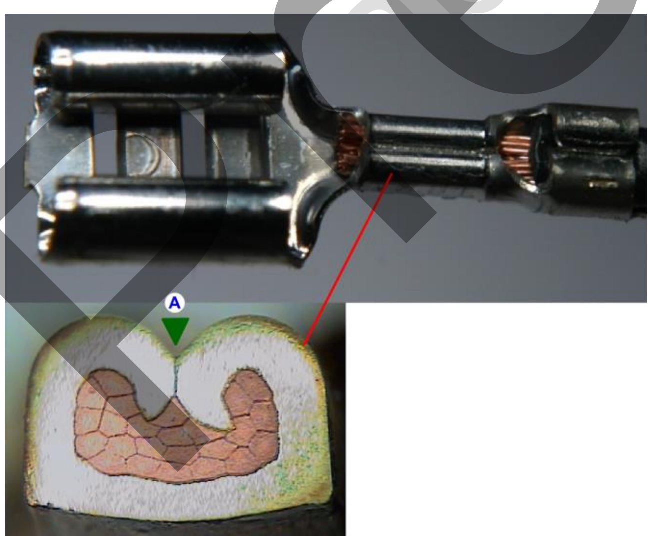
The color changes from a shiny orange-reddish shade to a matt dark brown surface, depending on the degree of oxidation (also called: passivating effect). This surface serves as a protective layer and prevents the penetration of oxygen or oxygen compounds such as water, thus stopping further corrosion and making copper very resistant to weathering.



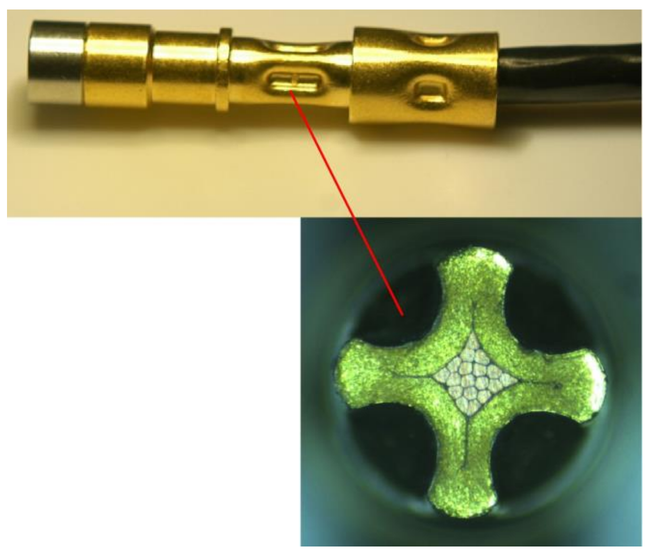
In crimping connection technology, this oxidized surface is undesirable because it has an electrically insulating effect and is responsible for increased transition resistances in a crimp connection. Due to the irregular pressing of the stranded conductor during the crimping process, this oxide layer is broken up. Together with the crimp contact, a friction-locked and keyed permanent connection with good electrical properties is created.

Conversely, this means that the more cavities and undeformed individual strands are visible in the micrograph, the worse the electrical and, of course, the mechanical properties of the crimp connection. Moisture can penetrate into existing cavities, which initially, in a normal environment, does not cause any further deterioration in the properties of the crimp connection. However, if the ambient conditions change, copper may also be attacked and destroyed ("pitting corrosion").

Of course, it is important that a created crimp also maintains its form. It's generally not a problem with the closed crimp barrel. But for the open crimp barrel the crimp form is key. When sheet metal is deformed, the material tends to spring back into its original shape after the bending process. This effect also occurs after the crimp flanks have been rolled in. To counteract this, the crimp flanks must touch and support each other (picture below: position A).

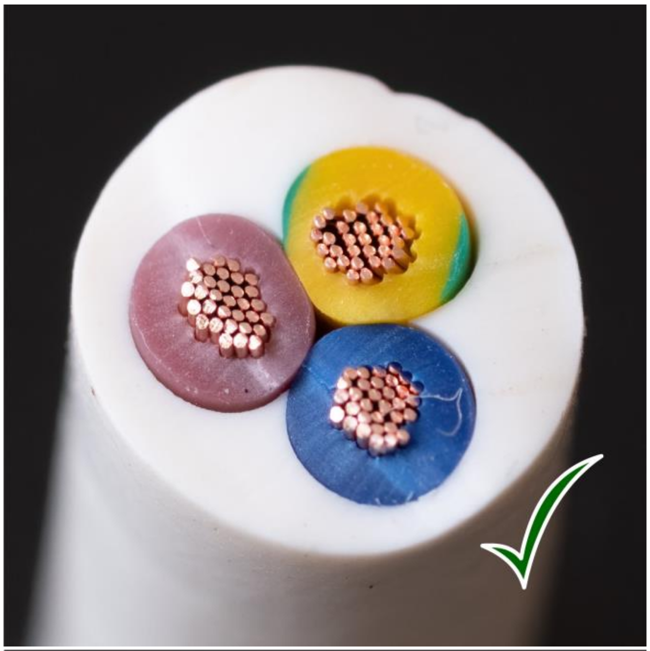


open crimp barrel:
The crimp flanks support each other (A)



closed crimp barrel

4.2.2 *COMPARISON: CABLE SHEAR VS. SIDE CUTTER*



The sectional view of a sheathed cable cut with cable shears. The geometries of the outer sheath, the inner conductors and the individual wire strands of the conductor are almost round.

The cut on the left was made with a brand new side cutter. Considerably more force had to be applied to cut the wire. The blunt cutting edges deform the sheathed cable and the inner conductors. The wire strands are also deformed by the squeezing process.

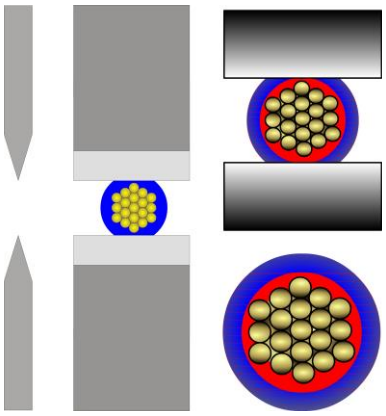
The cut on the right was made with a used side cutter. Due to the wear of the cutting edges, the amount of force required to cut the sheathed cable increases enormously.

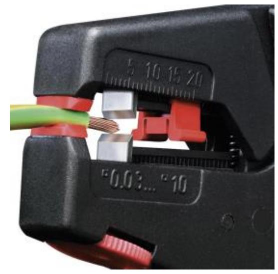
The quality of the cut surface has again extremely deteriorated.

Disadvantages of the side cutter when cutting sheathed cables:

- The geometry of the sheathed cable and the inner conductor are permanently deformed.
- The individual wire strands are deformed and no longer in the original compound.
- Due to the crushing, the individual wires are pressed into undefined lengths.
- The squeezed insulation threads show the poor cutting properties of the side cutter.

4.4.4 *WIRE STRIPPER WITH STRAIGHT BLADES*

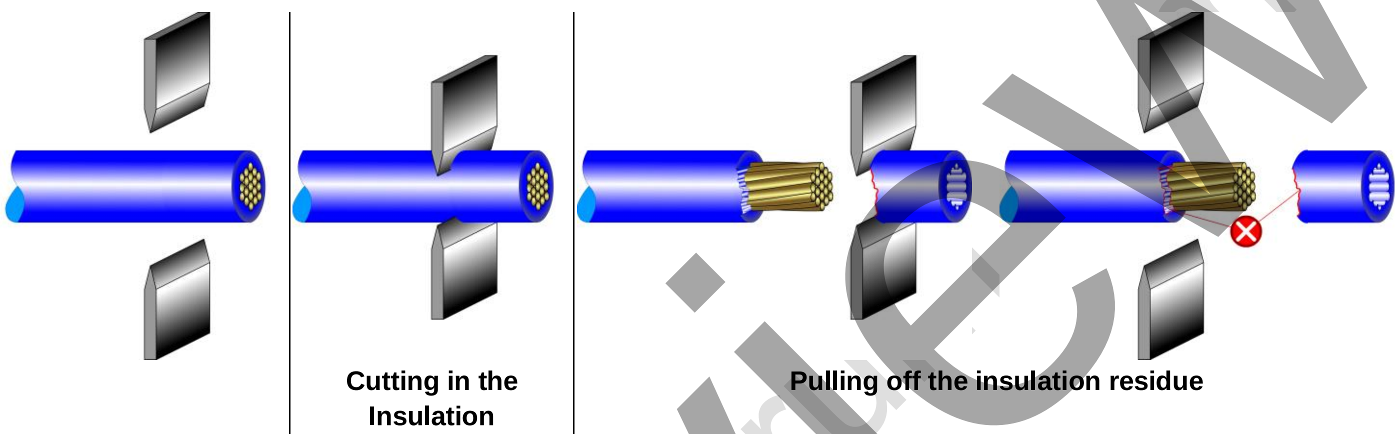




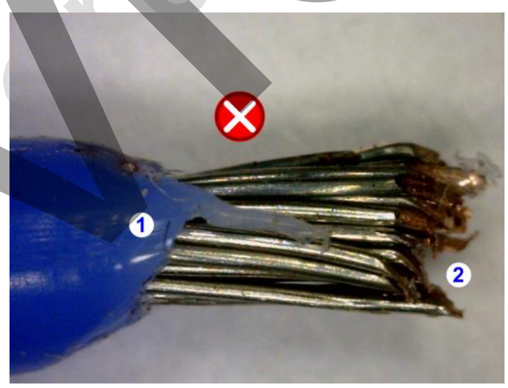
When stripping with standard hand strippers, mailnly straight stripping blades are used.

The disadvantage:
A large part of the insulation must be torn off when pulling off the insulation residue after cutting (red hatched area). This results in an unclean cut edge of the stripped insulation.

This can lead to the insulation in the wire crimp area being crimped during the subsequent crimping process or to the insulation crimp not being able to fully capture the insulation!



Error: Uncleanly cut, frayed insulation



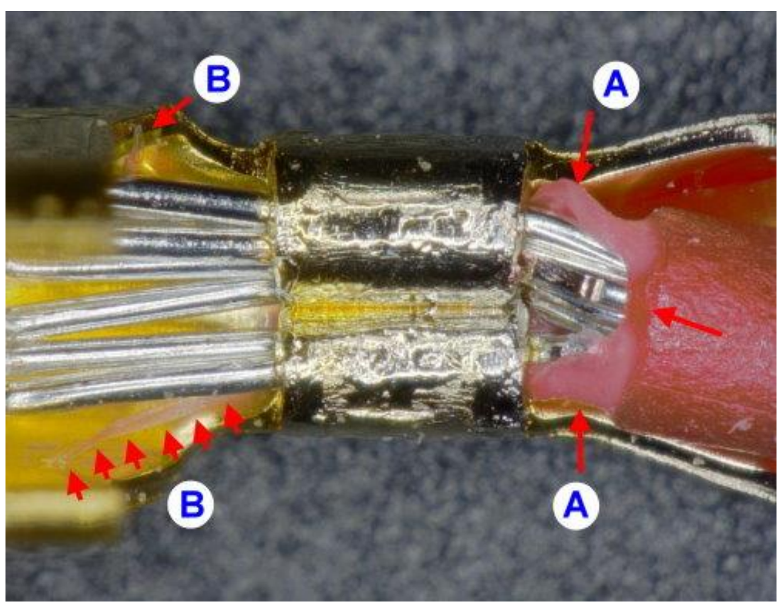
Error: (1) No clean cut due to straight and worn straight cutting blades in a wire stripper.

Error: Insulation thread in wire crimp area!

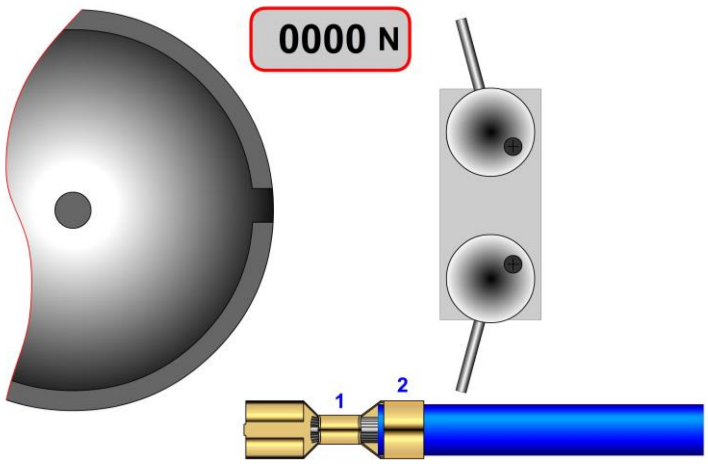
Improperly cut insulation (A), in addition to the visible damage to individual wire strands, causes the uncut insulation to be pulled. These "insulation threads" (B) are crimped to the conductor in the wire crimping area.

The effects are poorer electrical properties. The contact resistance is increased and, at higher currents, this also results in higher heat generation.

Important: Convert your hand strippers to V-stripping blades or use alternative hand strippers adapted to the geometric shape of the wire!



5.4.3 *Test Preparations*



The pull-out test is intended to check the mechanical strength of a crimp connection in the area of the wire crimp (1). Therefore, it is absolutely necessary that the crimp flanks of the insulation crimp (2) are open.

To prevent damage to the wire or the crimp connection when opening the insulation crimp flanks, there are basically 2 ways to prepare a crimp connection for the pull-out test:

1. The insulation crimp flanks are cut off **BEFORE** crimping.
2. The wire is stripped to such a length that the insulation crimp flanks do not touch the insulation when it is rolled in and the insulation crimp therefore has no function.

Pull-out test with closed insulation crimp:
With very small cross-sections and correspondingly small crimp contacts, opening the insulation crimp can lead to damage to the conductor. In this case, a pull-out with closed insulation crimp is recommended! In any case, the additional pull-out force must be determined with the corresponding insulation crimp dimensions. For this purpose, a crimp connection is created WITHOUT a filled wire crimp. The determined values are added to the required values. The prerequisite here is, of course, that the insulation crimp is executed properly. (e.g. NO piercing of the insulation by the crimp flank tips, etc.).

These test criteria must be specifically defined for the respective crimp connections. A blanket increase of the minimum pull-out forces is not permissible!

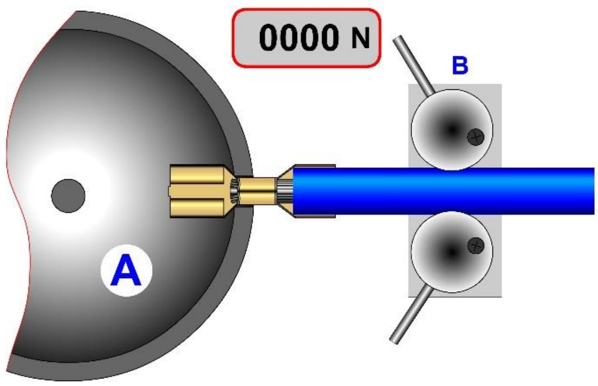
5.4.4 *Pull-Out Test – Procedure*

The crimp contact is hooked into the matching crimp contact receptacle (A).

Important: The crimp connection must not be damaged or deformed when inserted into the receptacle!

The clamping device (B) is closed and ensures that when the wire is pulled out of the crimp contact, the wire is fixed and does not slip through.

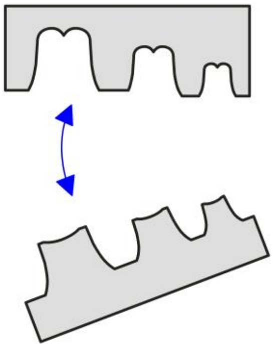
The crimp connection is now ready for the pull-out test.



Ideally, a pull-out test should be performed without manual intervention after inserting the crimp contact and clamping the wire. If pressure is applied to the contact receptacle (A) by hand during the pull-out test, this can lead to measurement errors, especially with small nominal cross-sections.

With the start of the pull-out test, the crimp connection is directly mechanically loaded. If the pull-out test is interrupted for whatever reason, the test must NOT be continued or restarted with the same specimen. The mechanical load that has already occurred may have already damaged the test specimen and thus the continued test would provide incorrect results.
In this case, the test must be repeated with a NEW test specimen in any case!

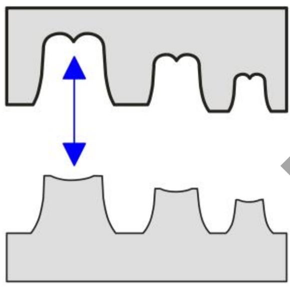
7.5 HAND CRIMP TOOL – TYPES



Hand crimping pliers with dies for larger cross sections.

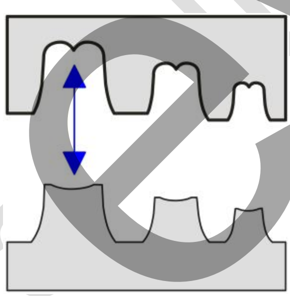
Radially closing crimp dies.

Alternatively, there are hand crimping pliers in which the design of the levers allows almost parallel closing of the dies. Compared to the standard hand crimping pliers, a better crimp quality can be achieved with this type of hand crimping pliers!



An example in the picture on the left: PEW 12 system crimp tool from Rennsteig

Hand crimping tools for small cross sections.



In addition to the nearly 100% parallel closing of the dies, these crimping pliers usually also have an integrated locator (1) as a positioning aid for the crimp contact, which also serves as a depth stop for positioning the wire (depending on the crimp contact).

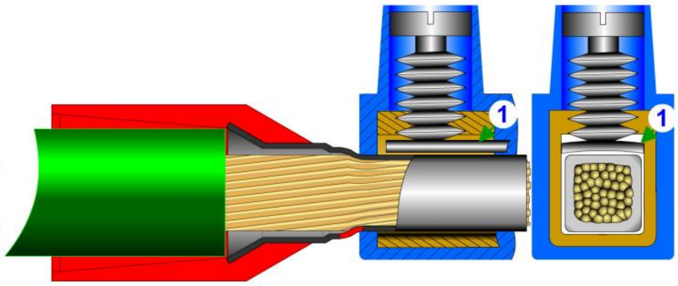
The type of pliers shown on the left is NOT suitable for making good crimp connections. This kind of tool does not have a positive lock which ensures that the crimp process is completely finished. Furthermore, the respective die set range is only designed for either the wire crimp or the insulation crimp.

For the preparation of an OK crimp connection, wire crimp and insulation crimp must be done in one crimping process. If the crimping areas are crimped one after the other, the 1st crimp may open and the crimp contact is bent or deformed by the crimping sequence.

Another disadvantage of this crimping tool is that no positioning aid can be fitted.

Attention: This kind of tools are pure DIY pliers and must not be used in the production of a cable assembly!

Every transition point in a connection basically generates a transition resistance. Increased contact resistance leads to increased heat generation at high current loads, which can lead to a fire hazard, especially with poor connections. In principle, the aim is to keep the contact resistance as low as possible in a connection between two terminals or components. So, initially this would speak against the use of a ferrule. Especially since it is known that optimum crimping between the stranded conductor and the ferrule is not self-evident when using hand crimping pliers.



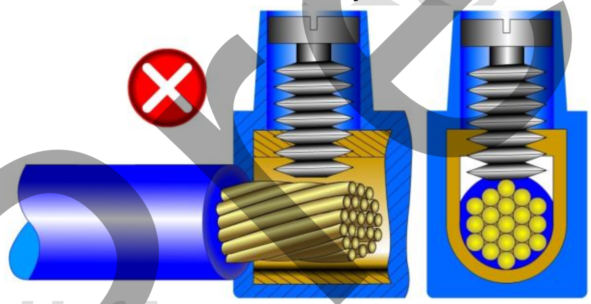
Screw terminals:
No direct contact of the screw to the ferrule. Pressing takes place via a pressure piece (1).

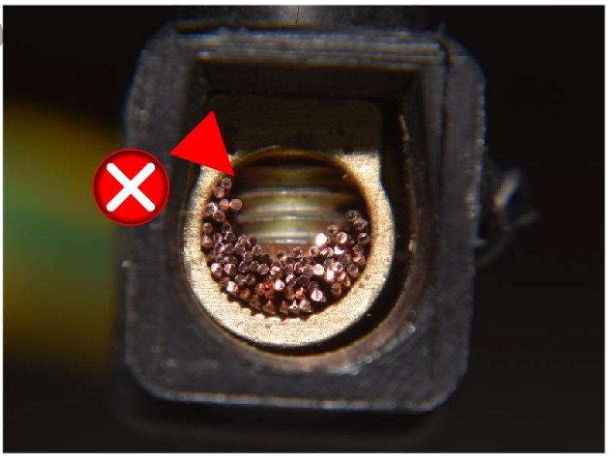
The use of ferrule has several advantages:

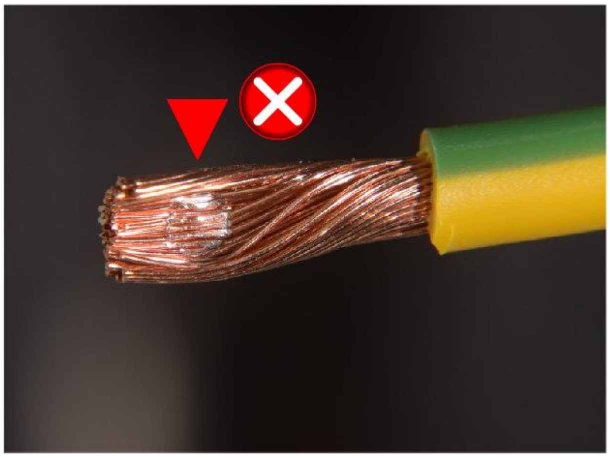
- The ferrule protects the individual wires of a stranded conductor against mechanical damage.
- Correct crimping of the ferrule and the stranded conductor breaks up the insulating oxide layer on the individual wires and creates an inseparable, form-fit, force-fit and, above all, compact connection with good contact resistance.
- The greatest advantage of wire ends with ferrules is that kinking of individual wires or broom-like opening is prevented. Everybody in the field of wire processing is familiar with this problem, when the stranded conductor of a stripped wire bumps against something and individual strands stick out. Or the unprotected stranded conductor has to be positioned in a spring clamp, and individual wires break off because they are not positioned correctly at the first attempt. A compact wire end fitted with a ferrule also offers many advantages in handling and, of course, in the safe positioning of the wire in the terminal strip when rewiring, e.g. in control cabinets or during repairs, often in quite narrow spaces.

A prerequisite for a crimp connection to work with a wire end ferrule is, of course, the correct assignment of the nominal cross-section of the wire to the diameter of the wire end ferrule. And ultimately also the use of certified, high-quality equipment.

Until the introduction of ferrules (in the 1960s), the end of the wire was either soldered or mounted directly in the screw terminal.







Screw connections in connection with a bare or soldered stranded conductor are generally not permitted! Depending on the current load, there is a great risk of fire!

The stranded conductor is not compacted (no breaking up of the oxide layer) and individual wire strands are damaged and/or squeezed off by the screw. Even with screw terminals that are specially designed for stranded conductors, there is no optimum compaction. In addition, the copper "flows" around the area of the screw. The result is that the connection loosens after some time.

10. *Turned Contacts – 4/8-Indent Crimp*

10.1 General

Turned (or machined) contacts are used in power and control lines in multi-pole plug connections. A classic turned contact is found, for example, in mains plugs via which a toaster or a coffee machine draws its current.

Turned contacts are machined from solid rod and are always the "closed barrel" type, meaning that the area where the wire will be inserted forms an unbroken, 360 degree cylinder.

Fig.: Turned contacts. Left: socket. Right: contact pin. (Source: Amphenol-Tuchel Electronics)

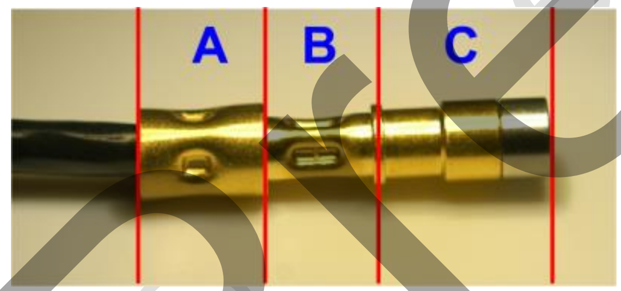
They come in different shapes and sizes and are primarily used where quality requirements are very high, such as in the military, aerospace and medical markets. Applications for the machined contacts range from computer interface connections to flexible production lines in the automotive industry.

Turned contacts are characterized by special processing criteria:

- Consistent crimp quality guarantees constant contact resistance.
- High corrosion resistance due to quasi cold welding.
- Processing of different conductor cross-sections can be realized with only one contact type.

Turned contacts are mostly processed in a closed frame crimp tool with 4 indenters that leave an 8-indent impression (4 or 8 dents) in the crimp area. To make it easier, we will subsequently call it "4-indent crimp".
When processed in a tool with open frame, it's generally a square crimp shape, sometimes a square shape with two additional indents or (much rarer) a B-crimp shape.

10.2 Contact Shape



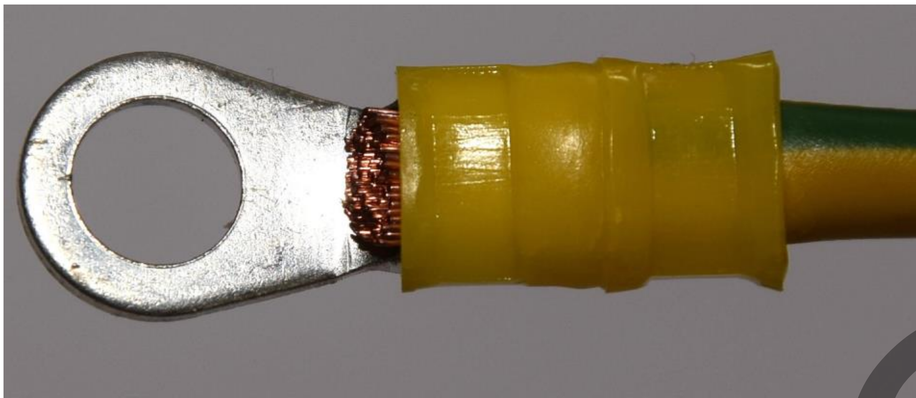
(A) The insulation fixation serves as relief for the wire crimp area. Turned crimp contacts are available with and without insulation fixation.
(B) The heart of the crimp connection, the wire crimping area.
(C) The contact area is designed according to the application. Basically, in a connection of crimp contacts, one is designed as a (male) pin contact and the mating connector as a (female) contact socket.

Important for crimp connections without insulation support(A): The crimp connection must be structurally protected against mechanical loads via the connector housing and/or the device housing directly after the connector housing. In the connector housing, this can be done by means of strain relief, in control cabinets or other component housings by means of appropriate fixation of the wires, e.g. by means of cable ties.

11. *Insulated Cable Lugs*

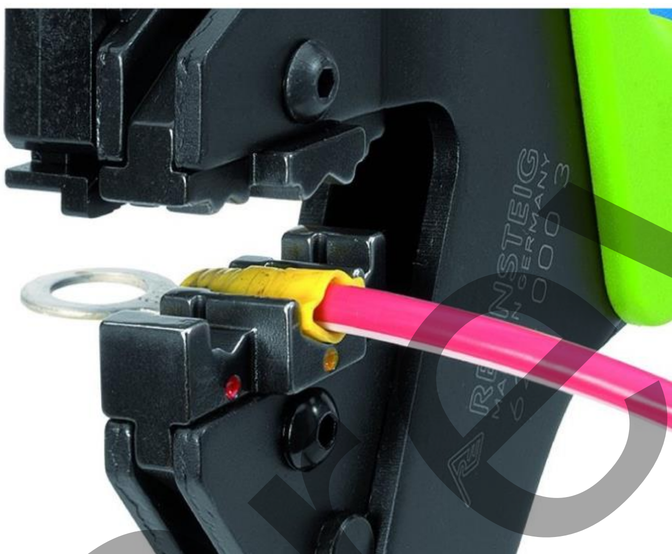
11.1 Processing Methods

(1) Partially insulated crimp cable lug
(2) Fully insulated crimp cable lug
(3) Partially insulated crimp cable lugs on strip (taped)



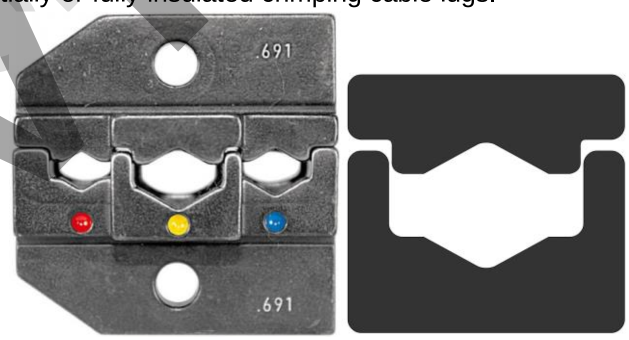
Crimped partially insulated crimp cable lug

11.2 Hand Crimp Tools and Die Sets



The individual contacts are processed with special hand crimping pliers.

Picture left: Dies in a hand crimping tool for processing partially or fully insulated crimping cable lugs.



Contour of the crimp die in the area of the insulation crimp for insulated crimp contacts with insulation fixation.

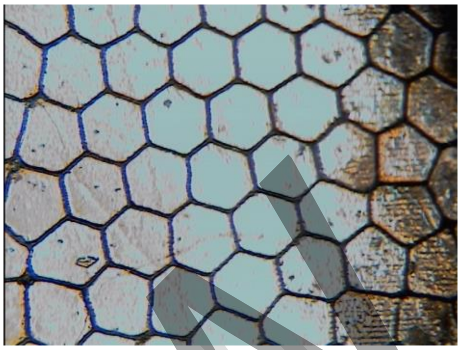
11.3 Crimp Applicators

Fig. right:
Crimp applicator for taped pre-insulated crimp terminals for use with standard crimping machines or fully automatic crimping machines.

12.2 Quality Requirements – The Micrograph

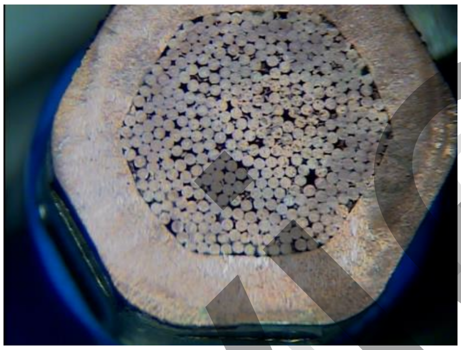
The basic characteristics of good crimping always remain the same.
They are the same regardless of the crimp contact variants:

- No cavities and completely, uniformly filled crimp sleeve.
- Complete, non-uniform, honeycomb deformation of the individual wire strands.
- Pressure marks and deformations on the inner surface of the crimp sleeve.
- No damage and deformation on the crimp contact.

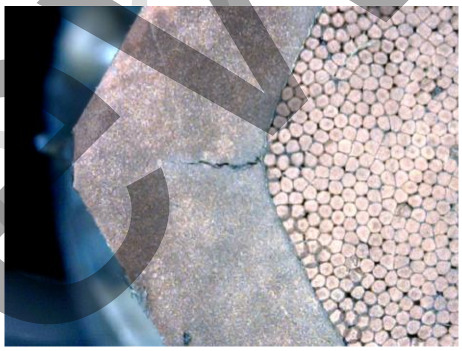


Hexagonal crimp

Micrograph OK



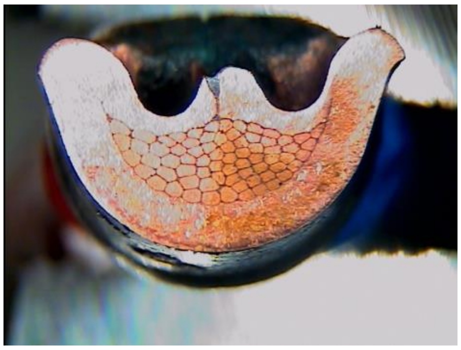
Micrograph NOK
Compression not sufficient!



Crimp contact damaged!

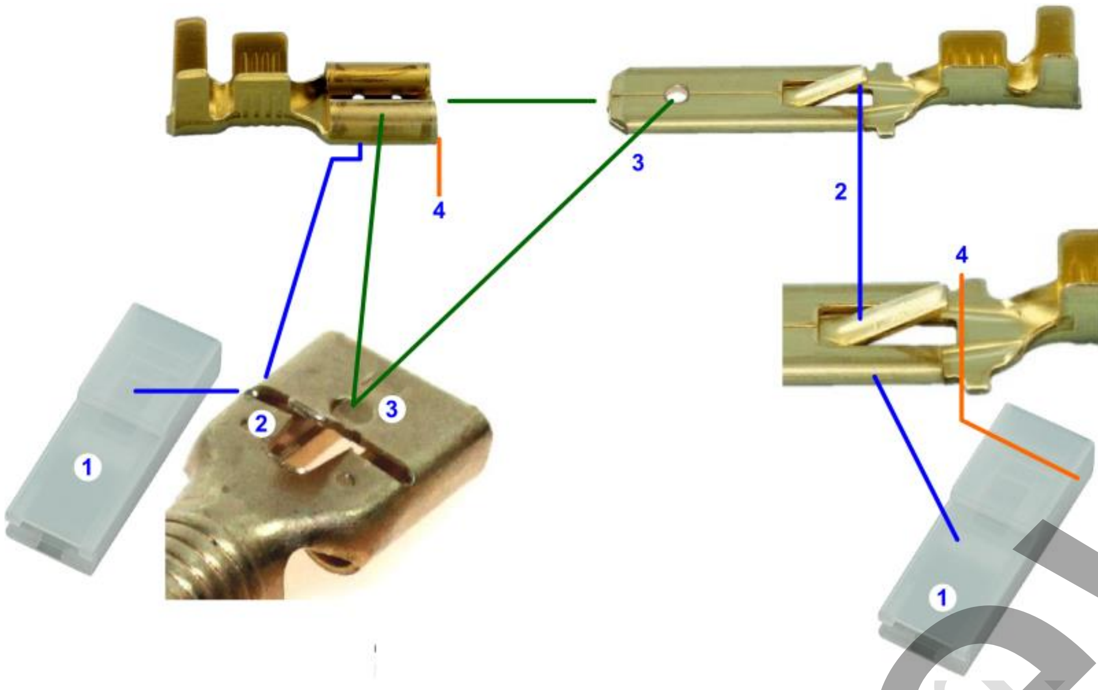
Hexagonal pressing with indent
(Dual system – Elpress)

Indent crimp



Double-indent crimp

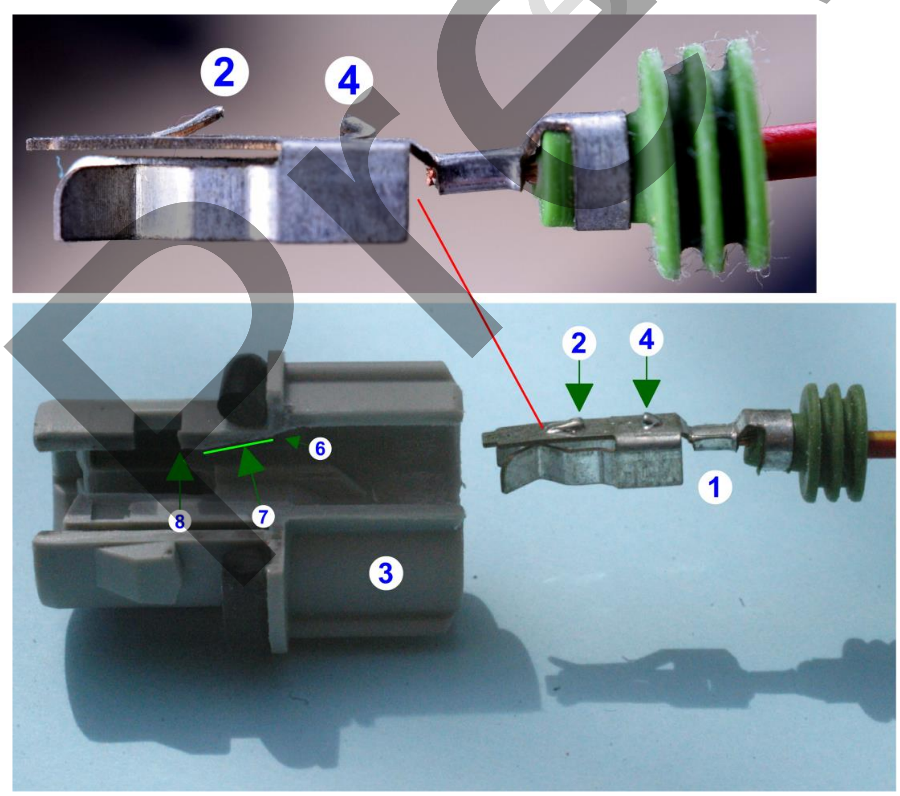
13.3 LATCHING FUNCTION – LATCHES



(1) Connector housing
(2) Latches for latching the crimp contact in the connector housing.
(3) Latching point and latching hole for fixing the flat plug latch in the flat plug receptacle
(4) Depth stop for positioning the crimp contacts in the connector housing

Latching functions ensure that the crimp contacts are held securely when mounted in connector housings and that an optimum electrical connection is created when two crimp contacts are joined.

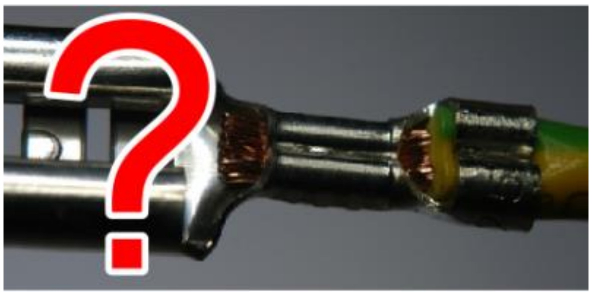
Latches on crimp contact



(1) Crimp contact
(2) Latch
(3) Connector housing
(4) Depth stop
(6) Stop
(7) Lead-in bevel
(8) Latching window

14. *GETTING GRIP ON CRIMP QUALITY – HOW TO START?*

14.1 INTRODUCTION



„We have been making our crimp connections with the hand crimpers recommended by the manufacturer for years. So, our crimp connections MUST all be OK!"

How great is the astonishment when, on closer inspection, one discovers that this is not the case? This chapter describes the procedure for (not only) bringing "hand crimping pliers production" to a "level" at which acceptable crimp quality can be achieved.

The basic rule for a good crimp connection is:

If the nominal cross-section of the wire matches the crimp contact and this combination matches the correctly adjusted crimping tool, then a good crimp connection can be obtained.

+ Crimp contact (terminal)
+ Wire (structure and cross section)
+ Crimp tool
+ Crimp tool settings

= Good Crimp connection