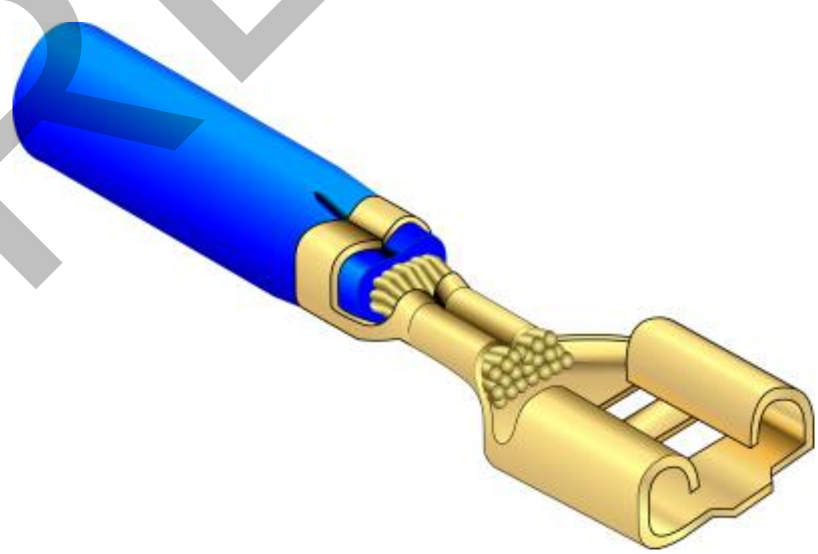
**Compendium - A Preview**
**To give you an impression of the structure and content of the e-book, we have created this preview for you. For this preview we have selected some pages from different topics.**

# Principles
# of
# Crimping Technology

**Compendium**
(unabridged version)

CRIMP ACADEMY
**www.crimp-academy.com**



PREVIEW

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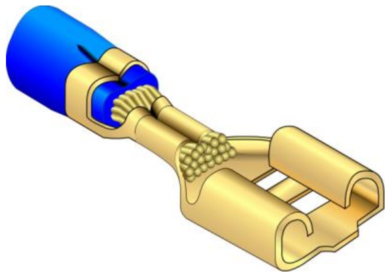
# 1. *Preface*



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.

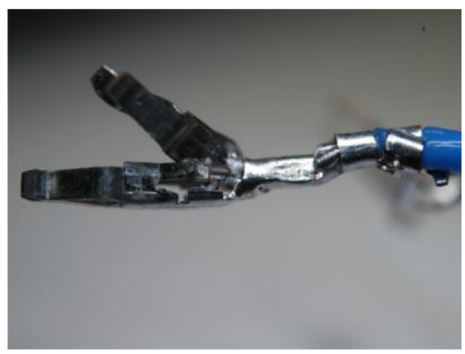
It was created based on current standards and the latest research, always with regard to their relevance in the "real world" of cable harness manufacturing.

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**

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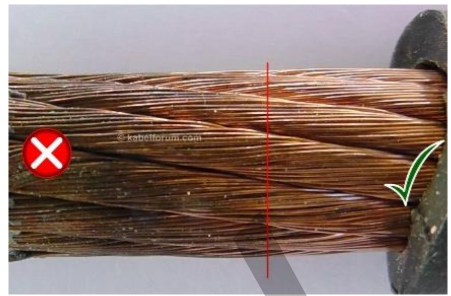
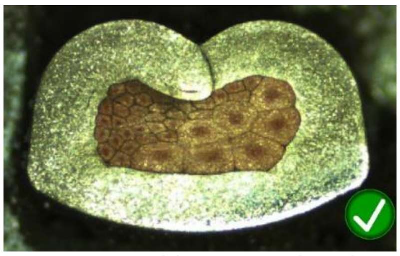
## 2.4 PROCESSING OF STRANDED COPPER CONDUCTORS



**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.

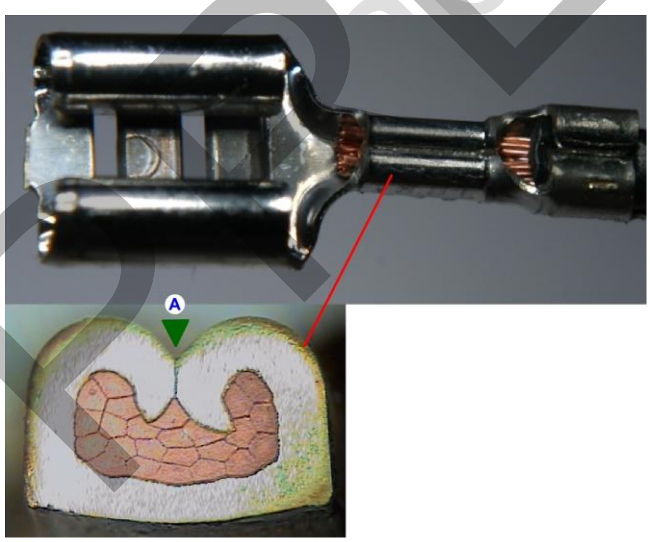
The color changes from a shiny orange-reddish shade to a matt dark brown surface, depending on the degree of oxidation (also called: passivating effect). This surface serves as a protective layer and prevents the penetration of oxygen or oxygen compounds such as water, thus stopping further corrosion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



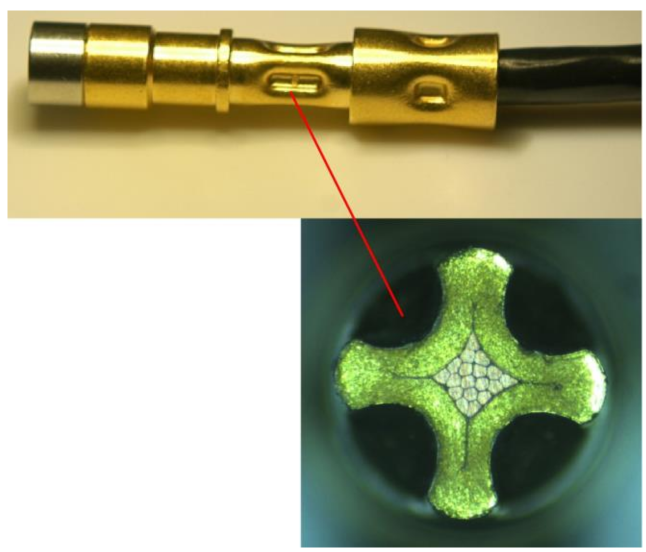
In crimping connection technology, this oxidized surface is undesirable because it has an electrically insulating effect and is responsible for increased transition resistances in a crimp connection. Due to the irregular pressing of the stranded conductor during the crimping process, this oxide layer 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).

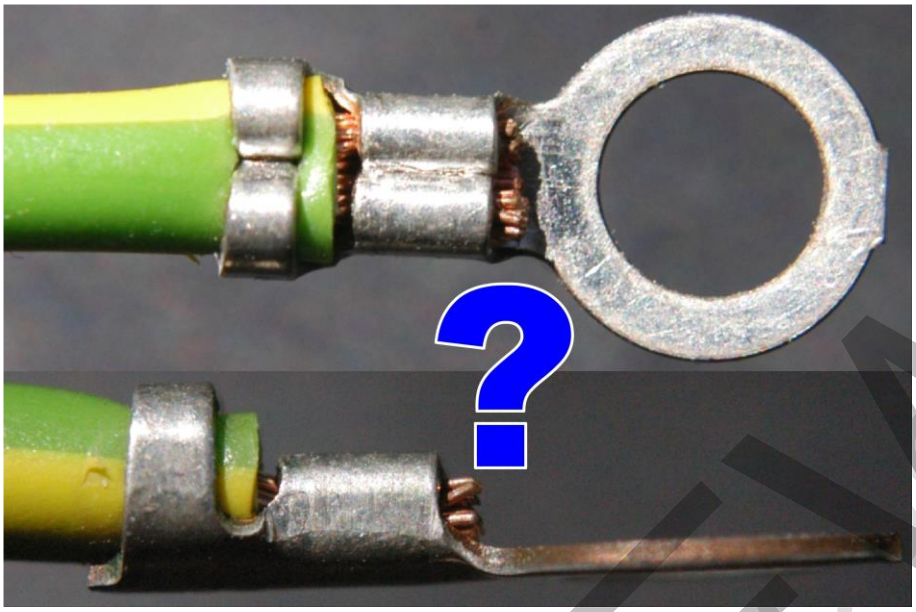



**open crimp barrel:**
The crimp flanks support each other (A)



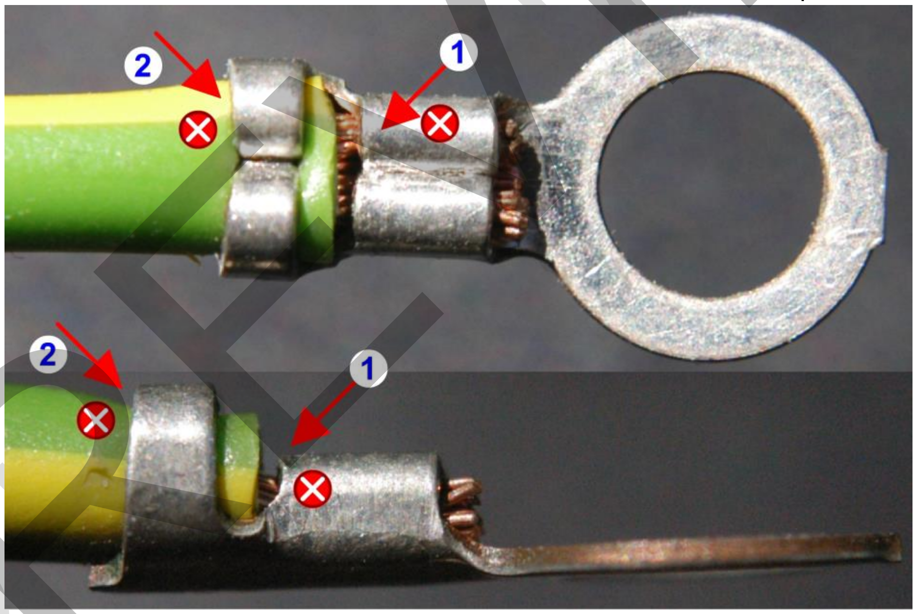
**closed crimp barrel**

## 2.9 The Objective of Crimping Technology




The assessment of the results of the individual work steps required for an ideal crimp connection is the bread and butter of wire processing. What is good, what is tolerable and what is bad? What consequences can faulty crimp connection have for the function of the wire harness? How can these faults be detected or avoided to begin with?

These are the questions that need to be answered. This documentation is intended to help with the search for answers.




(1) Critical error: Missing rear bellmouth (flare). Crimp connection is bad and must not be used!

(2) Tolerable error: Insulation crimp overcrimped.

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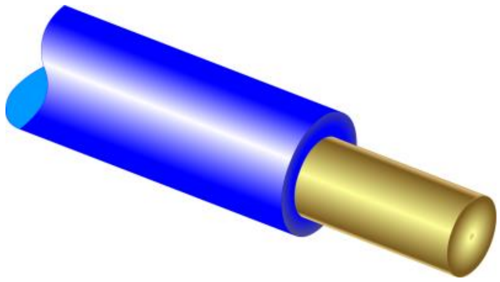
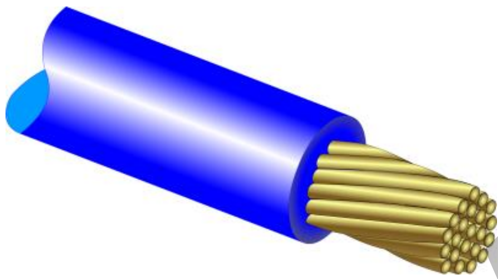
# 3. *THE CONDUCTOR*

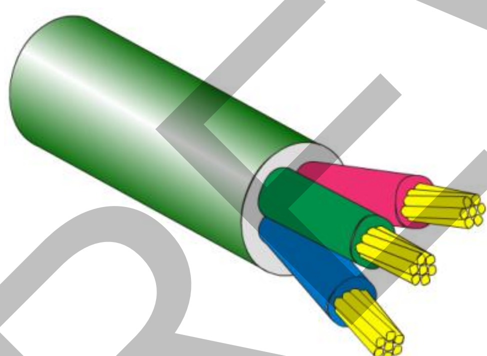
## 3.1 BASIC CONDUCTOR STRUCTURE



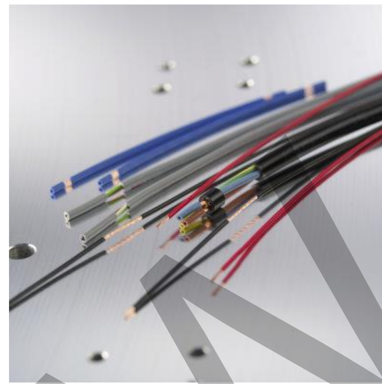
**Solid wire**
(Main use: electrical installations in buildings)

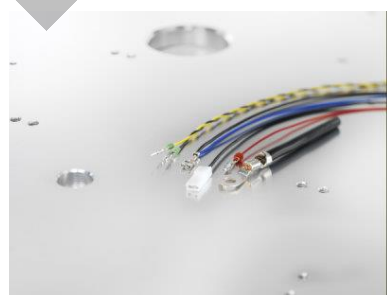


**Stranded wire**
The more individual wire strands there are in a cable, the more flexible the cable. The sum of the cross sections of all individual wire strands equals the cross section of the cable.



**Sheathed cables (Jacketed cables)**
Multiple conductors made of single wires are referred to as multi-conductor or multi-conductor sheathed cables.





Shielded cables
(Coax - Triax)

PREVIEW

## 3.12 Wire Stripping

### 3.12.1 Basic Rules of Wire Stripping

**Making a good, working crimp connection starts with properly stripping the wire. During the stripping process, the stripping blades cut the insulation, but must not damage or cut the strands in the process.**

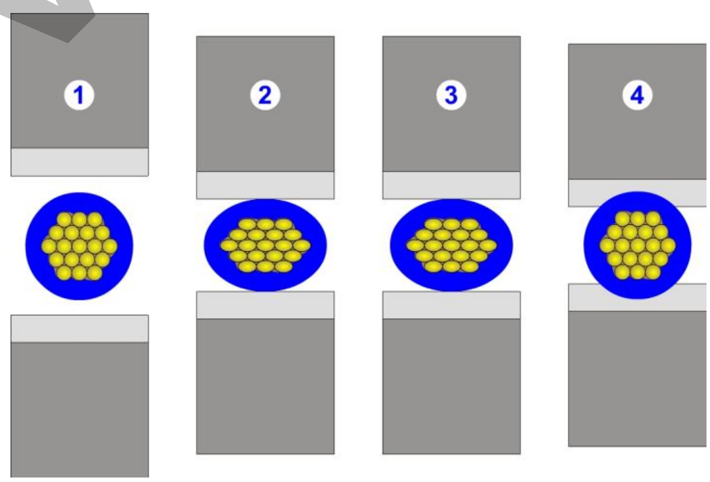
**Important: According to the official standards, all individual wire strands must be undamaged and complete!**

In the field, there are wires that have a large number of individual wires in relation to the nominal cross-section (finest-stranded wires). These conductors can often NOT be stripped without loss. Then, in deviation from the standard, the values defined in the customer's processing instructions or delivery specifications apply.

**Example:** Specification in % depending on the cross-section whereby the result is rounded down:
Up to 0.5 mm² = 5%; up to 0.75 mm² = 8%; above 0.75 mm² = 8%.

**Effective control in manufacturing:**
**When you find single, cut-off wire strands on the workstation or in the bin!**

If the cutting edge of the stripping blade hits the insulation (1), the cable is deformed (2). I.e. the insulation is compressed. Then the insulation "flows" around the cutting edge (3) and is cut (4).




This means that depending on how hard or soft an insulation is, the pressure of the blade must act on the insulation for a certain time until it is cut. The softer the insulation material, the longer this dwell time of the knife. If the dwell time is too short, the insulation is only partially cut.

Of course, the sharpness of the blade also plays an important role. If a knife wears out and becomes increasingly dull, the cutting properties deteriorate and as a result the dwell times become longer.

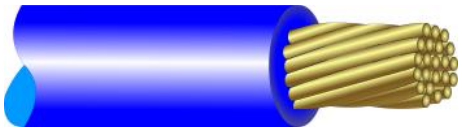
**Important:** Optimizing the dwell times increases the production speed. Regular controls of the stripping results give conclusions about the sharpness of the stripping blades.

PREVIEW

## 3.12.14 Error Descriptions during Stripping

### 3.12.14.1 Overview

**Good stripping vs. Bad stripping**



**Stripping OK**
**All single wires are present and undamaged**
**Insulation is cleanly cut**

**Indicated in % depending on the cross-section and the result is rounded down.**
**Up to 0.5 mm² = 5%* | up to 0.75 mm² = 8%* | over 0.75 mm² = 8%***

From a conductor cross-section of 25 mm², no more than 30 individual strands* may be cut off (finest stranded conductors).

***Attention**: The specifications may change, depending on customer specs & requirements!**


**Individual wires damaged and / or cut off**


**Single wire pulled**


**Surface of single conductor strands scratched on one side**

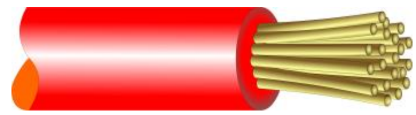

**Insulation improperly cut**


**Insulation threads**


**Insulation damaged**


**Insulation residues on the single strands**

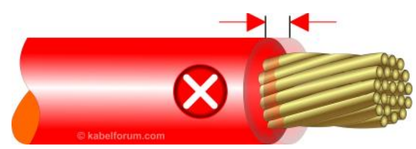

**Twisting of the individual strands lifted**



**Broom shaped conductor**

**Kinked wire strand**


**Conductor overtwisted**




**Variations in stripping length**


**Wire strands strongly oxidized**

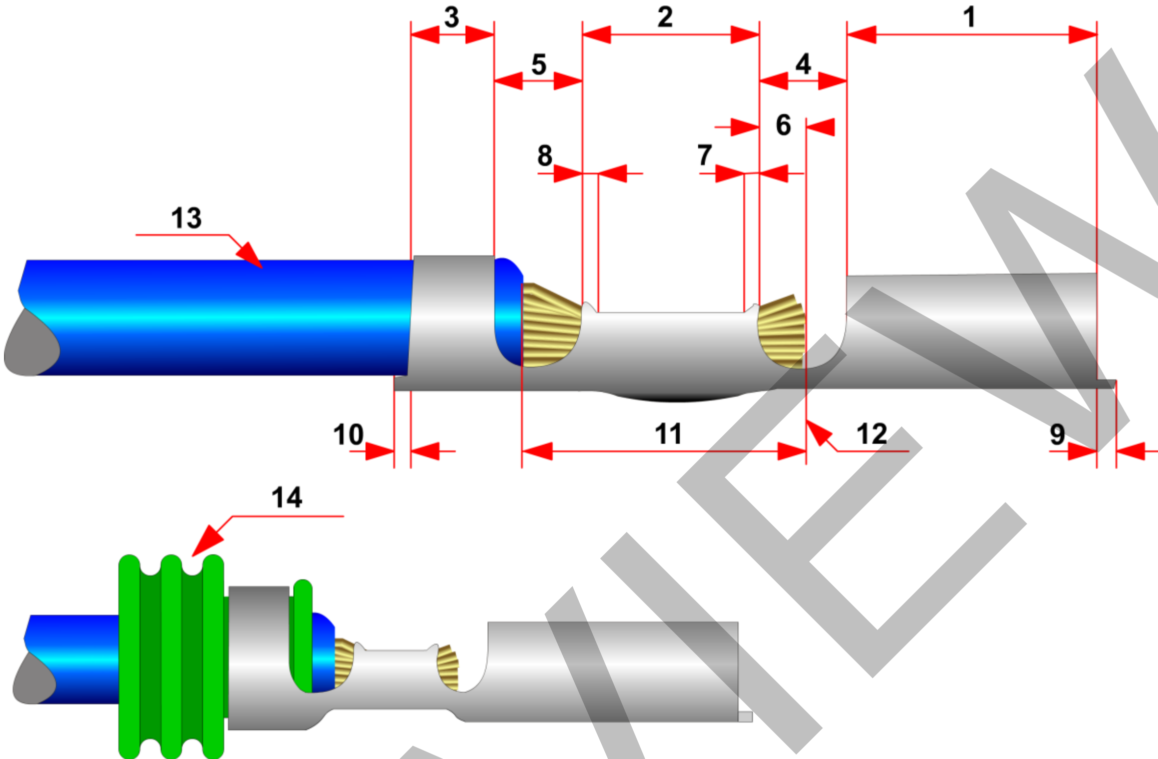

**Protruding Insulation („hollow“ cable)**

PREVIEW

# 4. *Crimping: Open Barrel Crimp Connectors*

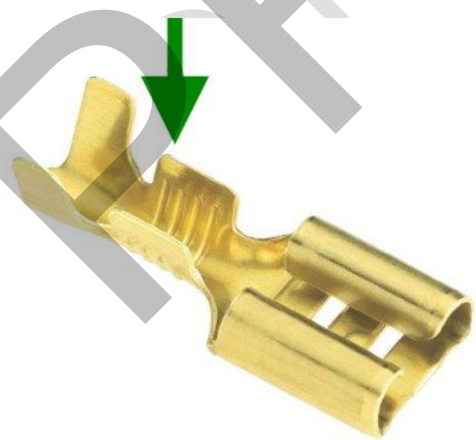
## 4.1 The Basics

### 4.1.1 *Terms & Definitions*




1 Contact area
2 Wire crimp (conductor crimp)
3 Insulation crimp
4 Transition to contact area
5 Transition to insulation crimp
6 Conductor protrusion
7 Bellmouth (front)
8 Bellmouth (rear)
9 Cutoff tab at the front
10 Cutoff tab at rear
11 Stripping length
12 Conductor end
13 Conductor
14 Seal

### 4.1.2 *Open Crimp Barrels*

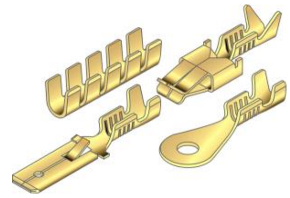
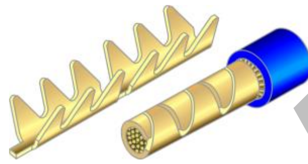
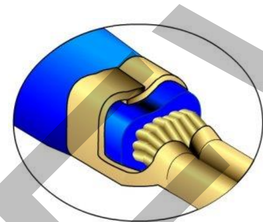
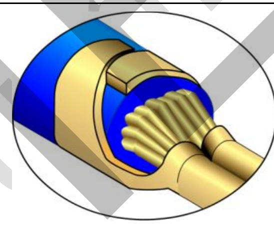
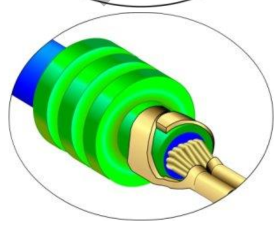
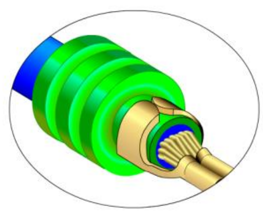
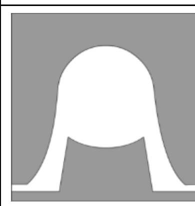
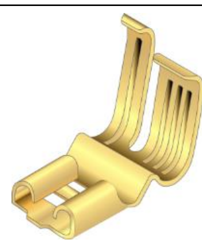
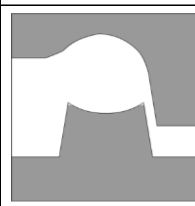


Cross-sections of up to approx. 50 mm² can be processed in open barrel crimp sleeves. The stripped conductor can be inserted from "above" into the open crimping area.

The areas of application for this contact variant include cable harnesses for the automotive, household appliance and aircraft industries. This contact variant is suitable for processing in large quantities. Wherever crimp connections have to be produced in large quantities, this contact variant is used. Processing is carried out on special production equipment which ensures almost 100% reproducibility of the processing quality, while at the same time producing large quantities.

PREVIEW

### 4.1.10 *OVERVIEW OF CRIMP SHAPES*

| | | |
|---|---|---|
| **B/F-Crimp** up to approx. 50 mm²<br><br>A standard crimp shape for open crimp sleeves. |  |  |
| **O-Crimp** up to 6 mm²<br><br>Wire end ferrule in open claw form for fixing the individual wires of a stripped cable. |  |  |
| **OV-Crimp** (for insulation crimps)<br><br>„OV“ stands for „overlap“<br>Insulation crimp form for open crimp sleeves. Often used for wires with reduced insulation thickness. |  |  |
| **O-Crimp, asymmetric** (for insulation crimps)<br>Asymmetrically wrapped around wire insulation.<br><br>Insulation crimp shape for open crimp barrels.<br><br>Application:<br>1. fixation of single wire seals<br>2. for wires with reduced insulation thickness | <br> |  |
| **O-Crimp, symmetric** (for insulation crimps)<br>Symmetrically wrapped around wire insulation.<br><br>Insulation crimp shape for open crimp barrels.<br><br>Application:<br>1. fixation of single wire seals |  |  |
| **Roll crimp**<br>Used for uninsulated flag terminals |  |  |

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### 4.1.11 *Assignment*

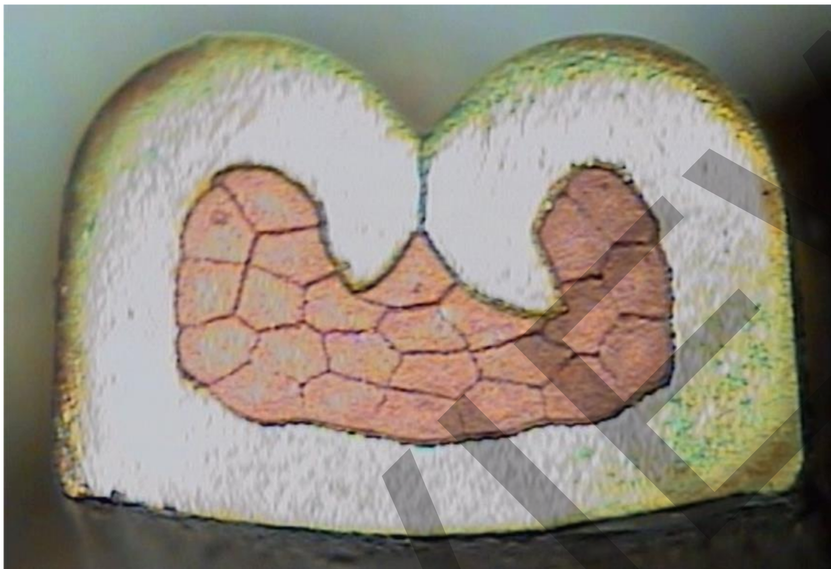
#### *4.1.11.1 Assignment Crimp Contact – Nominal Cross Section – Tooling*

For an optimal crimp connection, the following factors must match:

**+ Crimp contact**
**+ wire (structure and cross section)**
**+ Crimp tool**
**+ Crimp tool setting**

**=**

**Good Crimp connection**

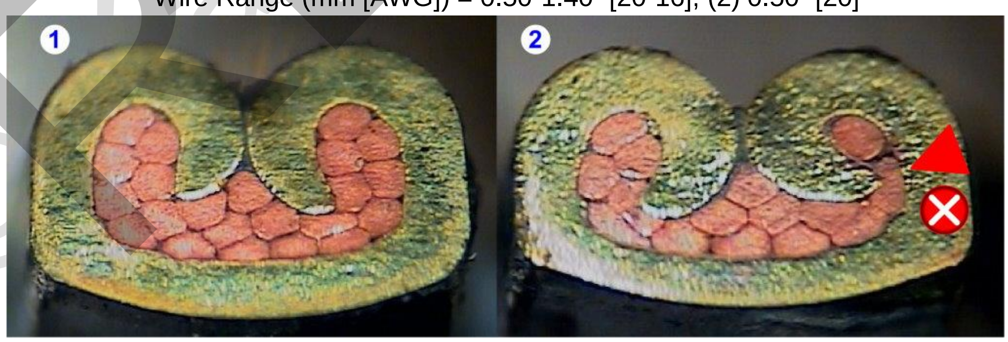


Crimp contacts can be designed for several cross sections or cross section ranges ("Ranges"). This occasionally leads to poor crimp connections, even if the official data and crimp specifications from the product description (catalog) are adhered to.

**The following example is intended to illustrate this problem:**

**Explicit notice:** This problem can principally occur with all crimp contact manufacturers. The following example has nothing to do with the qualification of a certain manufacturer.

Approved according to data sheet for nominal cross section(s):
Wire Range (mm [AWG]) = 0.50-1.40² [20-16], (2) 0.50² [20]

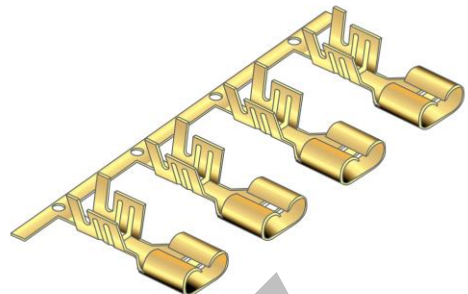



(1) cross section 0,75 mm²    (2) cross section 0,5 mm²

If the crimp flanks roll in unevenly, the permissible tolerances are quickly exceeded despite approval for this cross-section and the crimp connection is judged to be poor!

**Important:** Even official data sheets do not automatically guarantee good crimp connections.
Always check crimp connections via micrographs!

## 4.10 The Cut-off Tab – Connection to the Carrier Strip

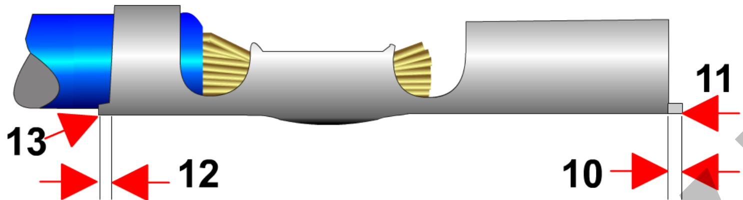


Crimp terminals are provided on reels, bound to carrier strips. This connection is separated shortly before the crimp flanks are rolled in during the crimping process. The remnants of these cut connections are referred to as cut-off tabs, which are of particular importance in the visual inspection of crimp connections.

Neither the insulation crimp flanks nor the functional area of a crimp contact may be deformed or damaged! A visible cut-off tab means that the insulation crimp flanks or the functional area of the crimp contact did not come into contact with the cutter during the separation process. Consequently, damage or deformation of both areas can be excluded.

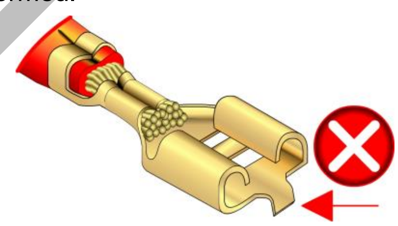
Undetectable cut-off tabs do not automatically mean that damage or deformation must be present. However, in such cases it is very time-consuming to check for these possible defects. It is easier if the tab can be recognized during the visual inspection. For this reason, it is important that tabs are visible or at least 0.1 mm long.

### 4.10.1 *Cut-off Tab Length*

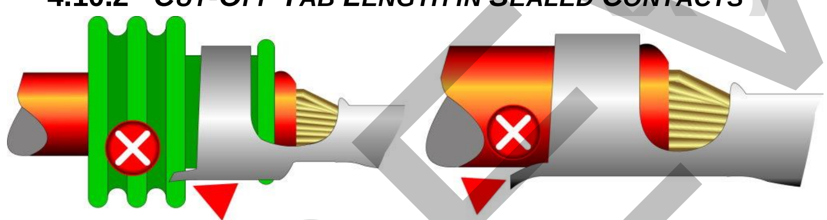



The cut-off tabs must be recognizable (at least 0.1 mm) and may be no longer than the thickness of the contact material. The length must not exceed 0.5 mm. The tabs must not be bent or deformed.

The cut-off tabs (10 + 12) and the burr (11 + 13) on these tabs must neither hinder nor influence the assembly of the contact in the connector housing or in corresponding mating contacts.

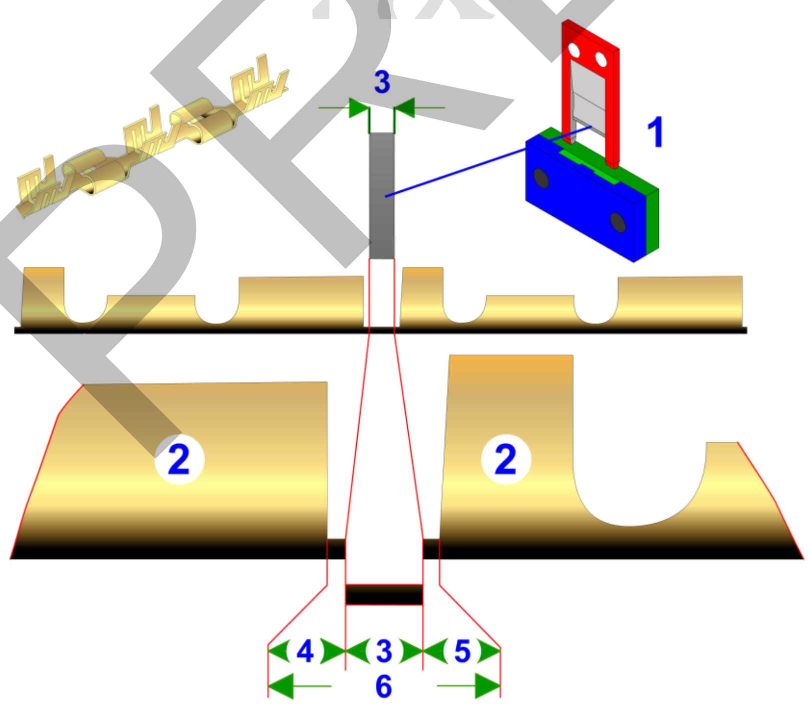


### 4.10.2 *Cut-off Tab Length in Sealed Contacts*



When processing single-wire seals, the cut-off tab (12) must not exceed a maximum length of 0.3 mm and must not damage the seals.

### 4.10.3 *Setting the Cut-off Tab Length in an Endfeed Applicator*




(1) Cutting unit
(2) Crimp contact
(3) Cutter thickness

The thickness of the cutting blade depends on the length of the connection (6) of the crimp contacts.

An example of calculation:

  1.50 mm connection (6)
- 0.25 mm front cut-off tab (4)
- 0.25 mm rear cut-off tab (5)
=1.00 mm thickness cutting blade (3)

## 5. *TEST METHOD AND APPLICATION*

**Important:** The basic test procedures in crimping technology are described in this chapter using the example of the open crimp barrel. In principle, the sequence of these test procedures is the same for all crimp contact variants. The requirements for the different contact variants of the closed crimp barrel (ferrule, turned contacts, etc.) can be found in the corresponding chapters.

### 5.1 FUNDAMENTALS AND GENERAL INFORMATION

Quality standards in crimping and pressing technology are becoming ever more stringent. Especially in the case of connections that are integrated into systems that directly serve the protection and safety of people (ABS anti-lock braking system, airbag, emergency call systems, aviation, medical equipment, etc.), the quality requirements are constantly being increased.

If a harness maker wants to be approved as a supplier, he must meet these high standards with his processing equipment and testing methods. And if the prospective electrician wants to take his skilled worker's examination or obtain the master craftsman's certificate, he must prove that he can meet the required quality.

The days when crimp and press connections were made with "flat nose pliers" or "hammer and chisel" are long gone. Today, even in the prototyping phase, care is taken to ensure that samples are produced with the processing equipment that will later be used in production.
Everyone is familiar with the reports of recall actions in the automotive industry, house fires due to short circuits, etc., or control cabinet wiring manufactured in Europe that arrives defective in the Far East and therefore a machine or entire production facilities fail to operate.

Quality control in production costs money! But it is necessary, because the follow-up costs in case of a failure of e.g. a crimp connection may be many times higher. The buzzword: "certification" is known today in every modern, quality-oriented company and the certificates are today a MUST for every expanding company.

A prerequisite for this is, in addition to the high-quality processing equipment, of course also an optimal, cost-effective quality management. A good quality system not only shows your prospective customers that your company values quality, but also demonstrates your expertise and can help you win new contracts.

In the world of crimping and pressing technology, there are five basic test methods:

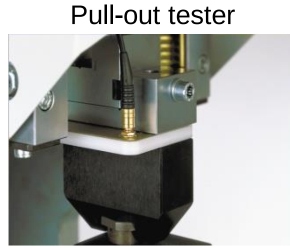
1. **visual inspection**
2. **measurement of crimp dimensions**
3. **pull-out test**
4. **micrograph + micrograph evaluation**
5. **crimp force monitoring (only in crimping technology)**

**Important:** These test methods complement each other and are the backbone of any quality assurance in crimping technology. Each test method on its own is NOT sufficient! Only the combination of these test methods enables a production of consistently high and reproducible quality of crimp connections!

Micrograph

Crimp height-measurement

Pull-out tester



Piezo position for crimp force monitoring

Crimp force monitoring control unit

## 5.2 Visual Inspection

Visual inspection of crimp connections is one of the most important tests in wire processing and crimping technology. The basic principles for a visual inspection are specified by the customer or the quality guidelines of the production. Many areas of a crimp connection can only be inspected with considerable technical effort. This in turn depends on the equipment used for production and, of course, on the quantities produced.

The requirements for a crimp connection and the corresponding background are described in detail in the topics "Crimping - Open Crimp Sleeve" and "The Closed Crimp Sleeve".

The most important aids for the employees in the production are appropriate visual boards, posters and, of course, instruction and training. Because only if the inspecting person knows where to look and how to look correctly, there will be a correct result of the inspection.

### 5.2.1 *The Visual Inspection Protocol*

Of course, this result can also be recorded in a corresponding protocol. The visual inspection record can also be helpful for practicing and learning, especially for new examiners. Until a corresponding qualification is achieved, the visual inspection protocol ensures that nothing is forgotten.

**The following is an example of a visual inspection protocol for the open crimp sleeve:**


| | Visual inspection of the connection: | OK | NOK |
|---|---|---|---|
| (1) | Rear bellmouth present / bellmouth correctly executed | | |
| (2) | Front bellmouth present / bellmouth correctly executed | | |
| (3) | Strands and insulation/seal visible | | |
| (3) | Stripping clean and good / all strands present | | |
| (4) | Strand protrusion visible (max.0.5 mm) | | |
| (5) | Contact area undamaged and straight | | |
| (6) | Wire crimp symmetrical and closed | | |
| (7) | Burr formation | | |
| (8) | Insulation crimp correctly executed. Position and design of the crimp flanks | | |
| (9) | Cut-off tabs present and visible (max. 0.5 mm) | | |
| (10) | No damage to the insulation (pressure marks allowed) | | |
| (11) | Seal correctly positioned and undamaged | | |
| (12) | Crimp contact overall straight and not bent | | |
| (13) | Uneven breakage of strands after pull-out test | | |

Comments:

**Date: _____________ Signature: _________________________**

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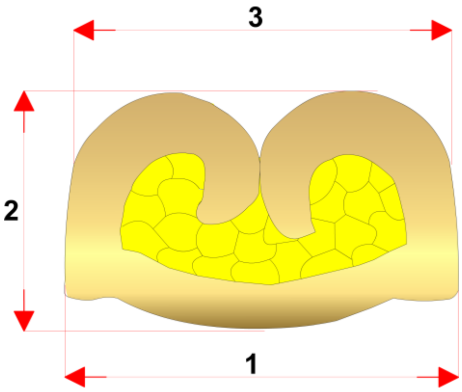
## 5.3 Measuring Crimp Dimensions

### 5.3.1 *Wire Crimp Height – Open Crimp Barrel*




The crimp height (2) is an adjustable dimension in the processing tool. The crimp height is specified by the contact manufacturer depending on the conductor/cross section. As a non-destructive test, crimp height measurement offers reliable quality control during ongoing production.

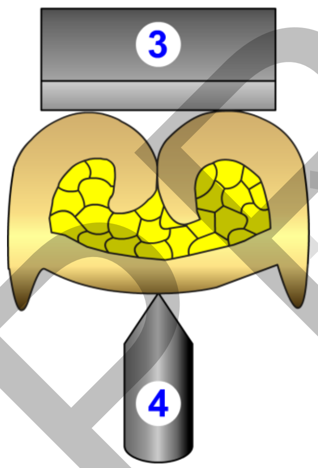
In the processing guideline (specification) which is defined for each crimp connection during design, the respective tolerances are usually defined in addition to the crimp dimensions.

The extent of the tolerance depends on the crimp height range in which the mechanical and electrical properties of a crimp connection are still OK with certainty. The tolerances specified by the customer are always decisive. These tolerances can also deviate from the actual specification of the manufacturer. This happens if the crimp connection is to be used for safety-relevant connections, for example.

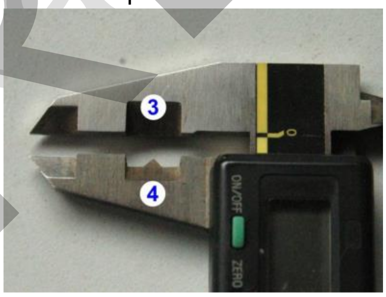
If no tolerances are defined for the crimp height, the following table provides a means of orientation. The crimp height tolerance is defined according to the cross-section ranges.

| Tolerances for the crimp heights without tolerance specifications | | |
|---|---|---|
| Cross-section range | | Tolerance |
| mm² | AWG | |
| 0.03 - 0.20 mm² | AWG 32-34 | +/- 0.02 mm |
| 0,20 - 0,50 mm² | AWG 24-20 | +/- 0.03 mm |
| 0.30 - 0.81 mm² | AWG 22-18 | +/- 0.04 mm |
| 0.50 - 6.00 mm² | | +/- 0.05 mm |
| 6.00 - 25.00 mm² | | +/- 0.10 mm |
| 25.00 - 50.00 mm² | | +/- 0.15 mm |

### 5.3.2 *Measuring Tools– Open Crimp Barrel*




When measuring the crimp height, the anvil (3) must always be positioned above the rolled crimp flanks and the measuring tip (4) on the crimp base.

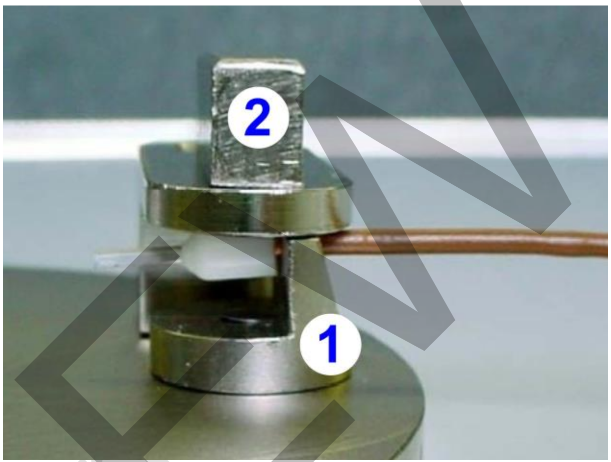



**Caliper with special grinding**

When measuring with a caliper, the measuring pressure is built up by hand. This means that the measuring result depends on the sensitivity of the operator. This measuring device may only be used by skilled and trained workers. Furthermore, this measuring device is unsuitable for small crimp contacts.

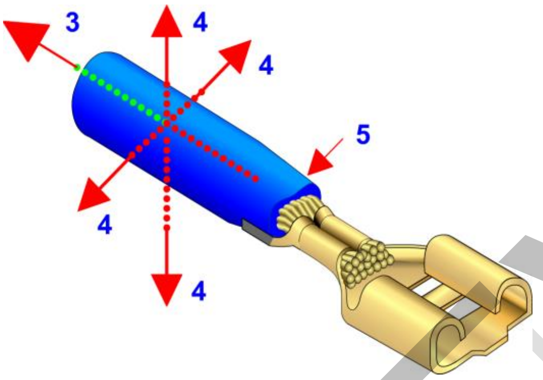

The picture on the left shows examples of universal crimp contact receptacles.

Position 3 shows the receptacle for ring tongues.




The picture on the right shows a special receptacle for wire-end ferrules: After insertion into the receptacle (1), a cover (2) is pushed over the wire-end ferrule. The ferrule cannot come out of the receptacle. The geometry of the receptacle prevents kinking. This means that it is not necessary to fix the ferrule by hand. An optimum measuring result is achieved.

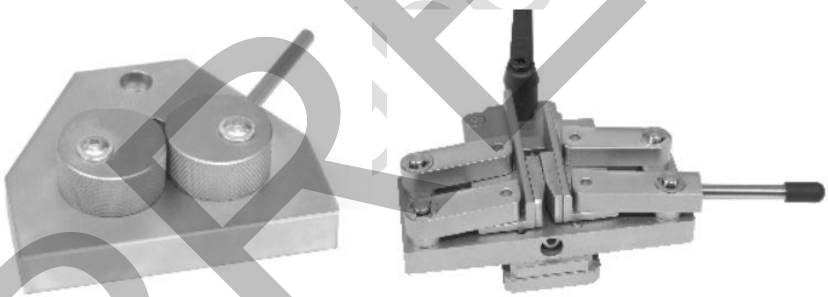
**Important:** When inserting the crimp contact into the receptacle, the crimp connection must not be damaged or deformed.




The pulling direction (3) must be made along the longitudinal axis of the contact and conductor! If the conductor would bend in one direction (4) directly after the wire crimping area, this would inevitably have an effect on the measuring result!

In order that the crimp contact and the wire can align themselves accordingly, the holder is mounted movably. When the pull-out test is started, the fixture rotates so that the crimp contact forms a line with the wire.

##### 5.4.2.3 *Clamping Device for the Wire*



Clamping devices that close in a self-tensioning manner are ideal. This means that the greater the tensile force or load, the greater the clamping force. During use, it is normal for the wire to slip a little through the clamping jaws at the start of the test.

Mechanical clamping devices are used for larger cross sections.
The forces that occur during the pull-out test are correspondingly high and require a considerably more massive clamping of the wire.

Pictured left: Schleuniger 28, a motor-driven pull-out tester with a measuring range of up to 10,000 N.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## 5.5 Micrograph Preparation

### 5.5.1 *Principles*

The micrograph shows the inner structure of the crimp connection in a cross-section through the crimp connection.

Micrographs help in the development of a crimp connection when determining the crimp dimensions and when checking the crimp quality of crimping tools.

When you purchase a new crimping tool, you will receive comprehensive documentation from your supplier. This includes, in addition to sample crimps, a micrograph of the crimp connection made with this tool.

This micrograph documents the crimping result with optimum tool setting and is your reference for all further micrographs of crimp connections made with this crimping tool.

Of course, this micrograph also shows you whether there were any errors in the crimp connection beforehand. The most common error is an incorrect assignment of the nominal cross-section of the wire to the wire crimping area of the crimp contact.

The reason: no or as small as possible stock-keeping and narrowing down of the crimp contact variants cause the crimp contact manufacturers to combine several conductor cross-sections into cross-section ranges.

For example: You have a crimp contact that is supposed to cover a cross-section range in the wire crimp of 0.5 to 1.5 mm². Then the crimping in the wire crimp is optimal for a conductor cross-section of (e.g.) 1.0 mm².

With a conductor cross-section of 0.5 or 1.5 mm², the crimping in the wire crimp can still be just within the tolerances. In any case, it will not be optimal. The larger this cross-section range of the crimp contact is designed (e.g.: 0.75 to 2.5), the greater the risk that the crimping in the wire crimp area will be outside the permissible tolerances.

Crimp connection OK

The crimping area is overfilled! Wrong assignment of crimp contact to conductor cross-section. The crimp contact is too small!

The crimp flanks are rolled in too far! Wrong assignment of crimp contact to conductor cross-section. The crimp contact is too large!

**Important:** Already during the assignment of the nominal cross-section of the wire to the crimp contact, within the scope of development, the quality of the compression of the conductor in the wire crimp of the crimp connection should be checked via a micrograph. And this applies in general to all crimp contact types!

If the development is completed and it is found during the production of crimp connections that the crimping is not optimal, the necessary changes (alternative crimp contacts) are usually no longer carried out. This is often due to the fact that there are no alternative crimp contacts available for the connector housing used that enable optimum crimping of the stranded compound. Consequently, suboptimal or poor crimp connections are produced. The tolerances are adjusted accordingly or the crimp connection is approved via a special approval.

If your customer submits such a combination to you in an order where the crimping result is poor according to the micrograph, you should point this out to your customer in any case! As a "crimp pro", offer your customer alternatives with which you can achieve an optimum crimping result. If your customer does not accept your alternatives, have your customer sign off on this "bad crimp connection" as intentional. This way you show professional competence and if the crimp connection fails you are exempt from all recourse claims!

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## 5.6 CRIMP FORCE MONITORING AND THE OPEN CRIMP BARREL

### 5.6.1 *THE PHILOSOPHY BEHIND IT*


Process monitoring of the crimping process ensures prompt detection of faults in crimp connections. Already during the production process the decision about good / not good of each individual crimp connection should be made and these should be immediately sorted accordingly.

A quality certificate should be available for each batch size, which is necessary as a pre-caution in the context of product liability and is required by many customers today as part of the certification process.

The following crimping errors should be detected:

- Missing individual strands in the conductor (cross-section changes).
- Insulation crimped in the wire crimp.
- Broken wear parts.

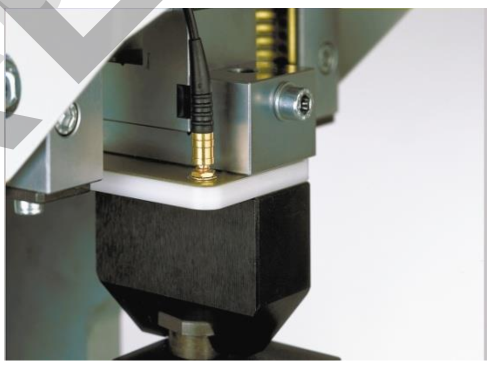
Crimp forces are rapidly changing force variables in the millisecond range with a typical range of a few 100N to about 40kN. Piezoelectric force sensors are used to measure these force characteristics. They are excellently suited for measuring dynamic and quasi-static loads.

The most common methods in crimp quality monitoring are pure force control or a combination of force/time control taking into account the working stroke of the crimping machine.

**Important** when using a crimp force monitoring system: crimping machine and crimping tool must be 100% OK!

Crimping tools that are rough-running or worn, or have too much play in the guide areas, are not suitable for use with a crimp force monitoring system. Of course, the same also applies to crimping machines. A check is only meaningful if the GOOD/BAD tolerance window can be set small enough, for example, to detect missing individual wire strands via the force measurement.

**Conclusion: The use of crimp force monitoring systems is ALWAYS associated with additional maintenance!**



Top tool fixture of a RAM crimp force monitoring system (by Komax)

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**Fully automatic crimping machine**
(by Komax)

Cutting to length, stripping and crimping are performed fully automatically at both ends of the wire.

In addition, a wide variety of options are available for processing the end of the wire (tinning, ultrasonic welding, double crimping, etc.).

Alpha series

---

**Fully automatic crimping machine - transfer lines**
(by Komax)

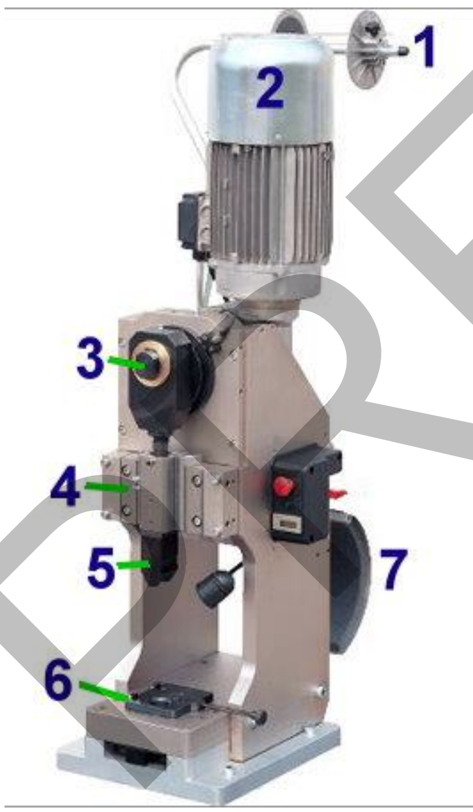
In addition to the individual processing and assembly of the wire ends, complex cable harnesses can be assembled fully automatically on transfer lines.

Zeta series

---

As with all modern fully automatic crimping machines, individual modifications and changes to the wire harness can be implemented by replacing individual modules. In this way, even wire harnesses with a customer-specific variety of versions can be manufactured effortlessly.

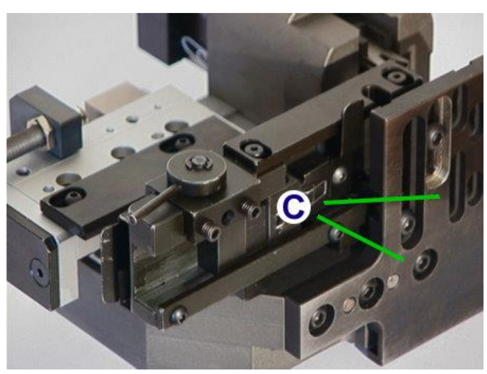
## 6.3 Structure of a Crimping Machine




(1) Receptacle for the contact coil
(2) Drive motor
(3) Eccentric
(4) Guide
(5) Ram (fixture for the crimping tool pressure block)
(6) Bottom tool fixture with quick clamping device for the crimping tool
(7) Guide plate for the crimp contacts

**Important:** The bottom tool fixture (6) of the crimping machine and the base plate (C) of the crimping tool must be flat and undamaged. When inserting the crimping tool into the crimping machine, it is essential to ensure that there are no residues from cut-off tabs, wires strands or insulation materials between the surfaces of the bottom tool holder (6) and the tool base plate (C).

Especially when using crimp force monitoring, damage to the bottom tool fixture (6) and the tool base plate (C) lead to incorrect measurements. As a result, higher tolerances must be set, which makes the detection of errors (e.g. missing individual strands) only possible to a more limited extent.

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## 6.4 The Stripper-Crimper (Open Crimp Barrel)

### 6.4.1 *Basics and Philosophy*

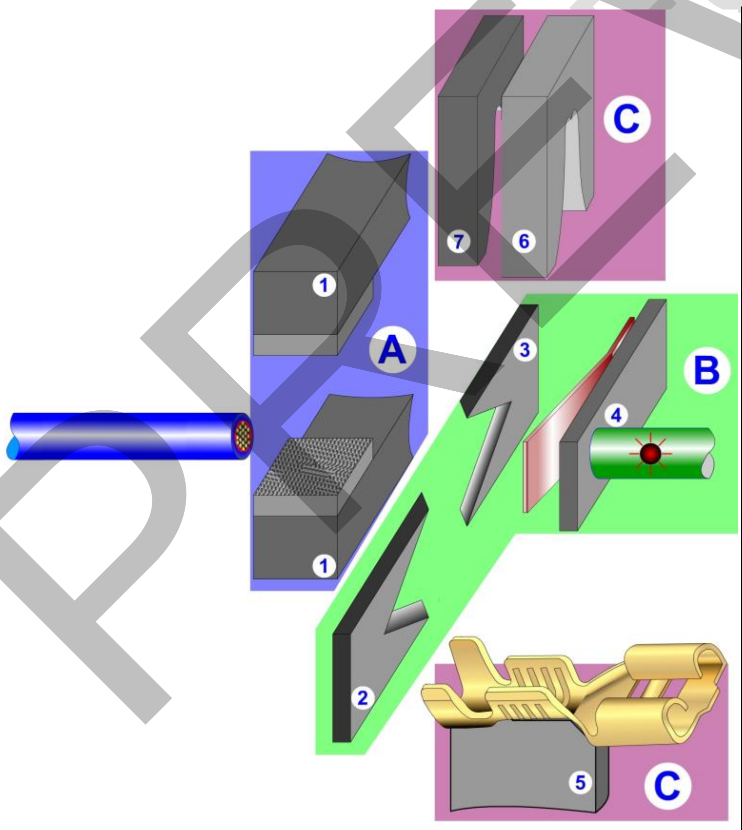

**Stripper-Crimper KM3011**
Manufacturer: AAC / KMI
(A) Crimping tool
(B) Stripping unit

With the Stripper-Crimper, the stripping and crimping process is carried out in one work cycle. The advantage: Optimal positioning of the stripped wire in the crimp contact. Particularly with smaller nominal cross-sections, manual insertion and positioning of the stripped wire is subject to errors. These errors are virtually eliminated by using stripper crimpers. Of course, an optimal adjustment of the individual components of the machine is important for this purpose.

Stripper-Crimpers are mainly used when the ends of the wire cannot be processed on fully automatic machines (e.g. multi-core sheathed cables) or for small quantities.

Stripper crimpers should always be used when the nominal cross-section is smaller than 0.5 mm². In this cross-section range, the crimp contacts are small, which makes correct, manual insertion of the stripped wire considerably more difficult. (Position of the wire in the crimp contact.)

### 6.4.1 *Stripper-Crimper: The Functional Units*




Stripper-crimpers are available in various designs. The schematic sequence shown here illustrates and describes the basic processes, irrespective of the technical design.

In general, the stripper crimper consists of 3 components:

(A) Gripper unit
(B) Stripping unit
(C) Crimping applicator

(1) Gripper (2) Movable stripping blade (3) Fixed stripping blade (4) Sensor holder with sensor and spring plate (5) Anvil (6) Wire crimp (7) Insulation crimp

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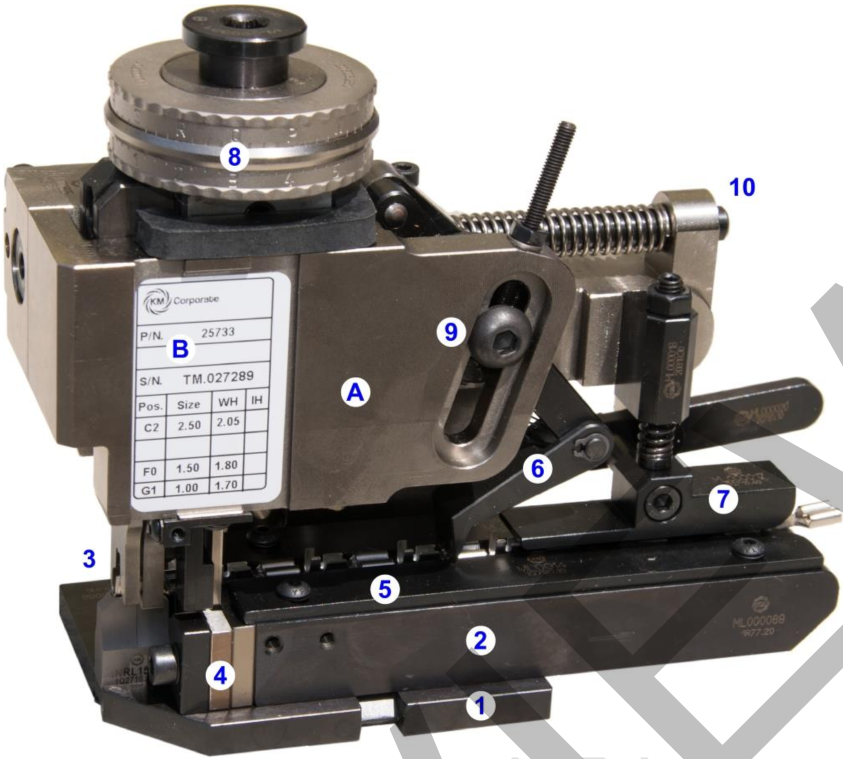
### 7.1.2 *Crimp Applicator: Definitions*

**Endfeed Crimp Applicator**

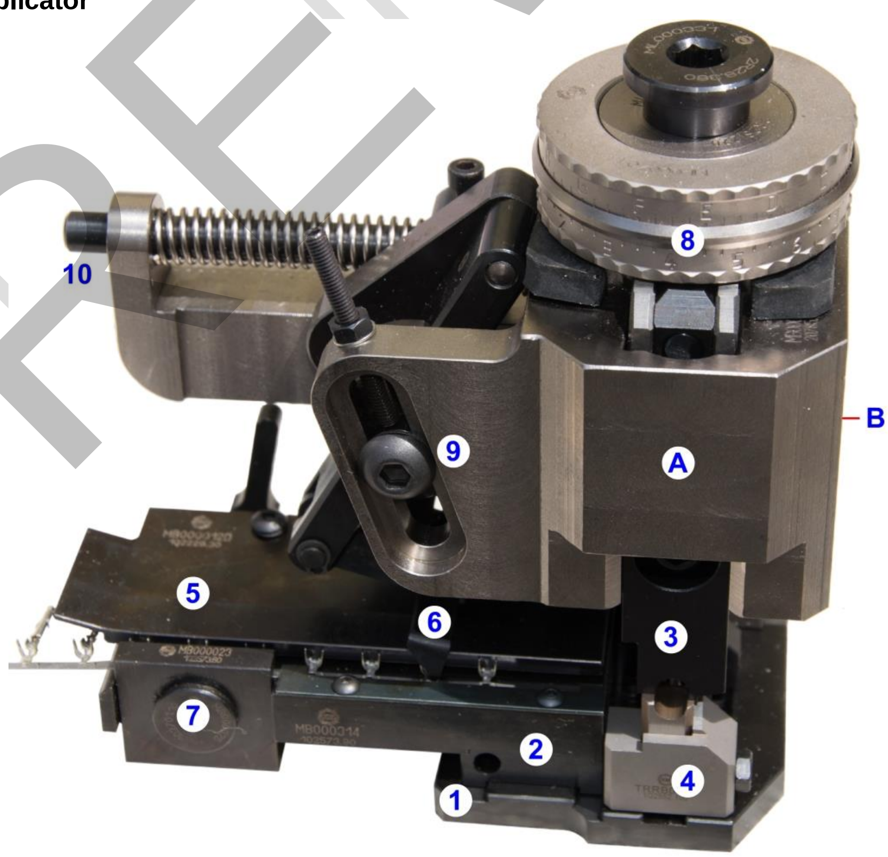



(A) Tool body
(B) Identification label
(1) Tool base plate
(2) Tool table

(3) Wearing parts kit
(4) Shear unit
(5) Contact guide
(6) Feed finger

(7) Contact brake
(8) Ram (top tool fixture)
(9) Adjustment: Feed stroke
(10) Adjustment: Feed position

**Sidefeed Crimp Applicator**

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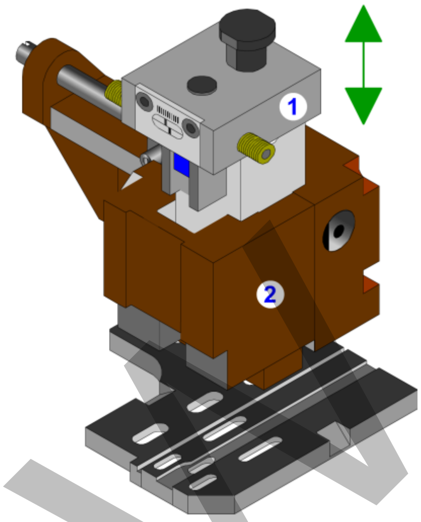
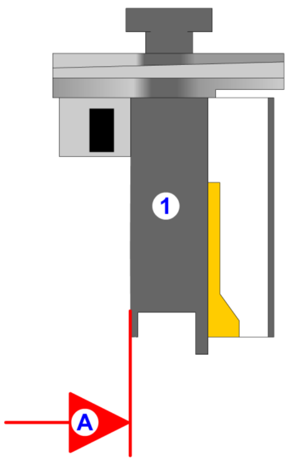
## 7.2.1 REFERENCES IN THE SIDEFEED CRIMP APPLICATOR

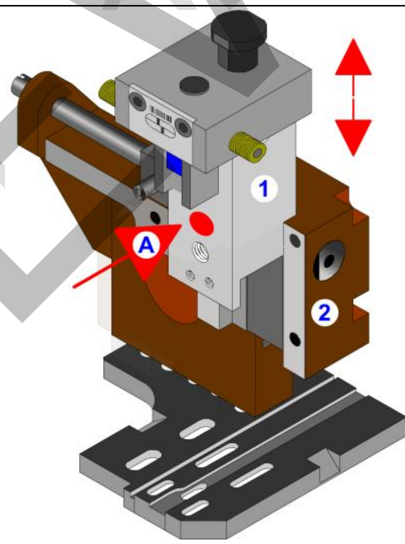
The ram (1) is guided in the base body (2) of the crimping tool. It must move easily and without play.

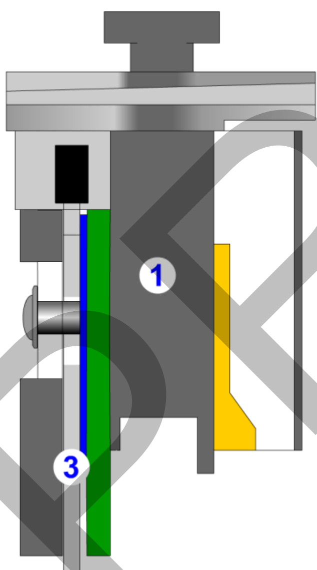



The surface (A) on the ram (1) is the reference surface for all assemblies in the crimping tool.

If a crimping tool is set up, all parts are positioned and fixed in relation to this reference surface.



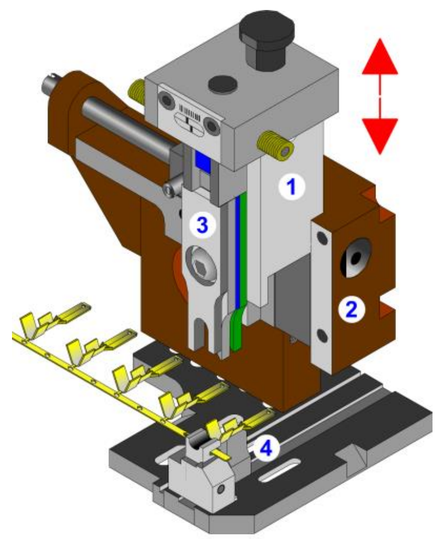



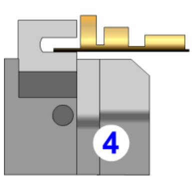

**Step 1**

The wearing parts kit (3) with wire crimper, spacer plate, insulation crimper, spacer ring and the pressure piece.

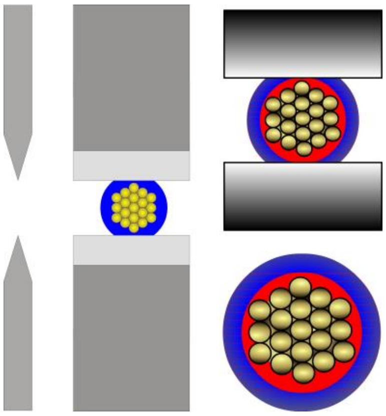
**Step 2**

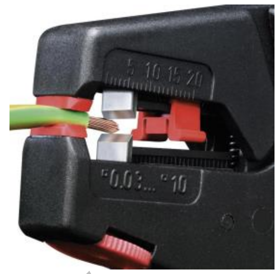
The anvil (4) with the shear unit for separating the crimp contacts from the carrier strip.



### 8.4.4 *Wire Stripper with Straight Blades*

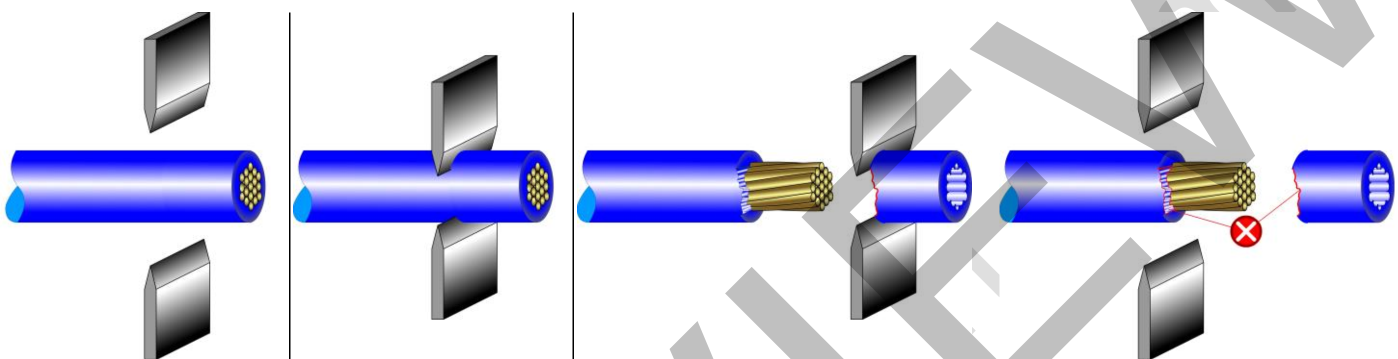




When stripping with standard hand strippers, mailnly straight stripping blades are used.

**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!



**Cutting in the Insulation**

**Pulling off the insulation residue**

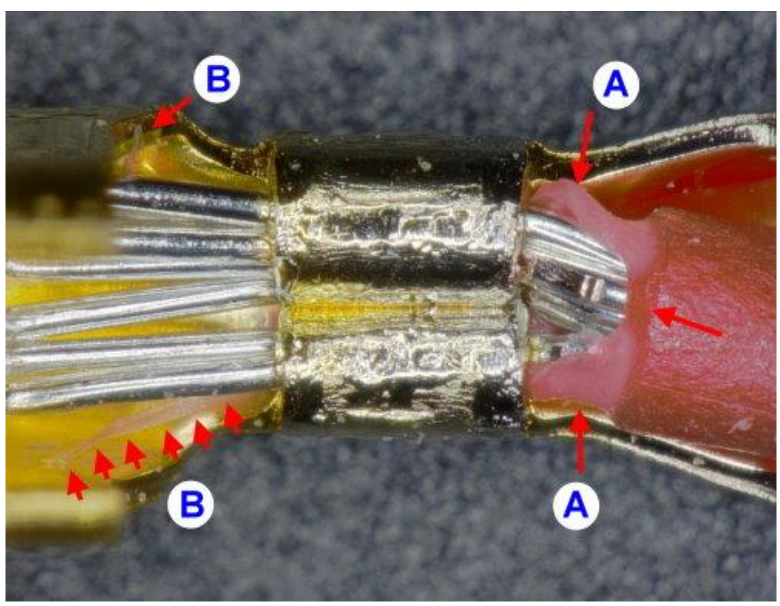

**Error:** Uncleanly cut, frayed insulation


**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!

PREVIEW

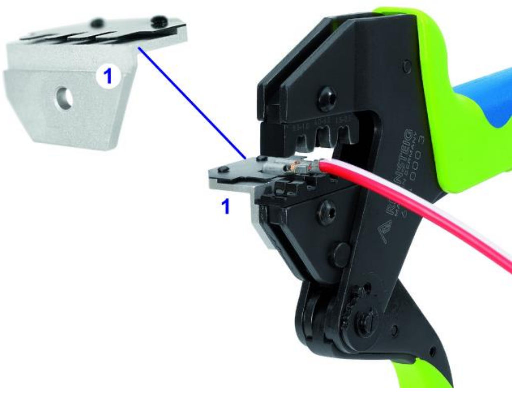
## 9.15 Working with Hand Crimp Tools – Open Crimp Barrell

**The crimping result decides whether your hand crimping pliers are suitable for your application!**

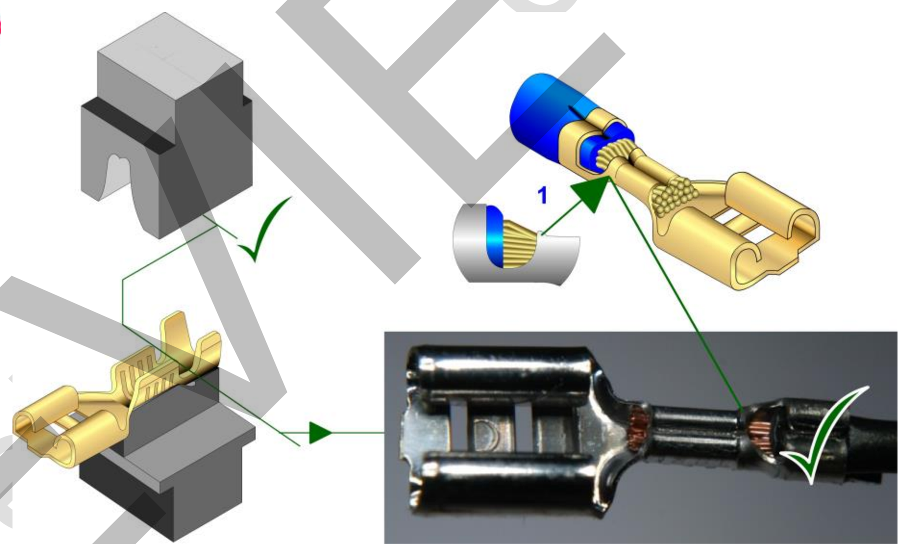
Every new hand crimping tool can be verified by checking the crimp connections made with it.

**Important:** If the crimp connections are OK, then the hand crimping pliers are also OK.
By constantly checking the crimp quality, the quality and condition of the hand crimper are checked at the same time with each crimp. With a brand product, many thousands of good crimp connections can be made. Of course, it is important that the tool is handled with care, which should really be a self-evident fact.

### 9.15.1 *Positioning Crimp Contacts – Insertion Depth*




A correctly mounted positioning aid matched to the crimp contact is absolutely essential for creating a good crimp connection with hand crimping pliers.




**Crimp contact position OK!**

The rear bellmouth (1) prevents a predetermined breaking point between the solid crimped stranded conductor and the flexible area of the wire.

**Important:** The smaller the crimp contact, the smaller the runouts, the more precise the positioning in the crimping tool must be.

With a cross-section of 0.50 mm², the rear bellmouth (1) must be 0.40 mm long. The size of the bellmouth depends on how the crimp contact is positioned in the die of the hand crimping tool.

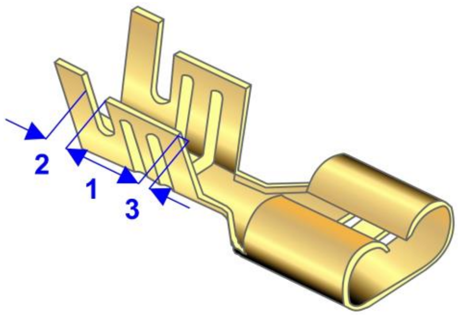
| Cross-section | | Length | Tolerance |
|---|---|---|---|
| **mm²** | **AWG** | | |
| 0.03 - 0.56 mm² | AWG 32-20 | 0.25 mm | +/- 0.15 |
| 0.30 - 0.81 mm² | AWG 22-18 | 0.25 mm | +/- 0.15 |
| 0.50 - 2.50 mm² | | **0.40 mm** | **+/- 0.20** |
| 2.50 - 6.00 mm² | | 0.60 mm | +/- 0.30 |

PREVIEW

## 9.21 Work Instructions: Creating a Crimp Connection

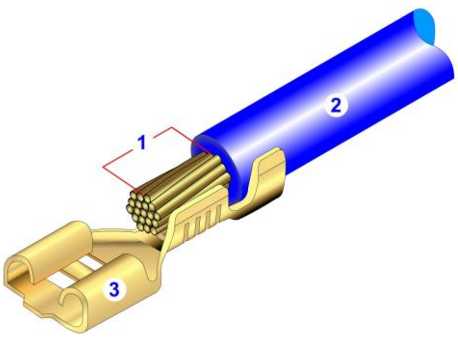
### 9.21.1 *Determining the Stripping Length*

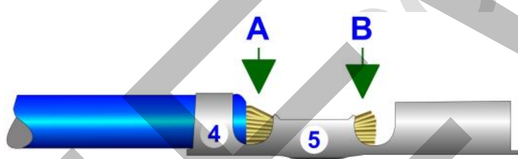
The stripping length is included in the specification of the crimp contact. If the stripping length is not specified, the correct stripping length must be determined.




**Calculation:**

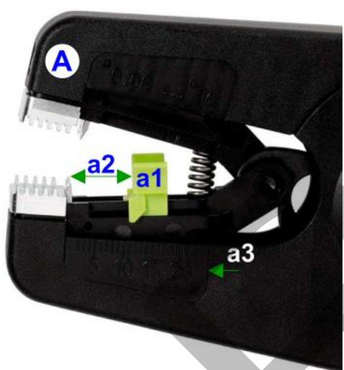
| | | |
|---|---|---|
| (1) | Length of the wire crimping area (e.g.): 5.0 mm | 5.0 mm |
| (2) | Distance between wire and insulation crimp:<br>(e.g.) 2.0 mm : 2 = 1 mm. | + 1.0 mm |
| (3) | Conductor protrusion (0.1 to max. 0.5 mm) | + 0.2 mm |
| | **Stripping length:** | **= 6.2 mm** |




**The stripping length (1) is correct if:**
(A) Insulation and conductor are visible between the insulation crimp (4) and the wire crimp (5).
(B) A conductor protrusion is visible behind the wire crimp. (0.1 to max. 0.5 mm)

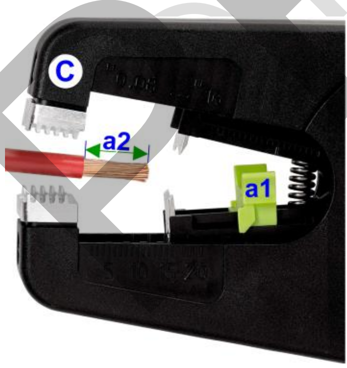
### 9.21.2 *Standard Stripping Pliers*




Note: Minimum requirement for hand strippers is the use of V-shaped blades!

**Set the stripping length.**
**(A)** Move the stop (a1) until the stripping length (a2) corresponds to the specifications for the crimp connection.


**(B)** Insert the wire straight into the stripper.
Push the end of the wire onto the stop (a1) and close the stripper completely.




**(C) Check stripping length**

Insert the stripped wire into the crimp contact. Check the positions according to the crimp contact type. If necessary, correct the stop (a1).

**Check:**
- Wire crimp completely filled?
- Position end of stripped conductor = ok?
- Position cut edge of insulation = ok?

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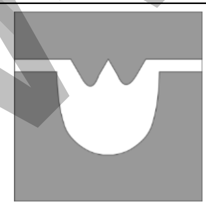
## 10. *Closed Crimp Barrels*

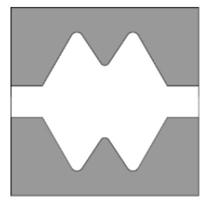
### 10.1 Types and Crimp Shapes

**Indent Crimp** 0.75 to 300 mm²
-Tubular cable lugs + connectors (standard version)
-Ring type terminal ends for solderless connections, without insulating sleeve, (acc. to DIN 46234)
-Pin type terminal ends for solderless connections, without insulating sleeve, (DIN 46230)
-Insulated cable lugs
-Tubular cable lugs + connectors for fine-stranded conductors
-Compression cable lugs + connectors, AL compression cable lug

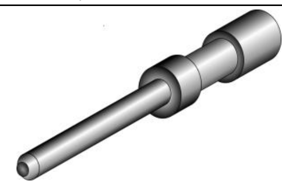
**Double Indent Crimp**
0.5 to 16 mm²
Tubular cable lugs + connectors (standard version - VDE 0220)

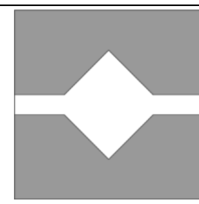


**"WM" Crimp shape**
6 to 240 mm²
Tubular cable lugs + connectors
(acc.to VDE 0220, fine stranded conductors IEC 60228)

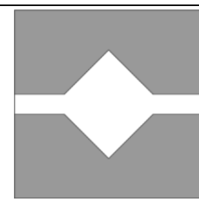


**Square crimp shape**
0.1 - 25 mm²
Machined contacts



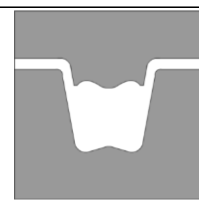


**Square crimp shape**
Wire-end ferrules + twin wire-end ferrules
0.14 to 16 mm²

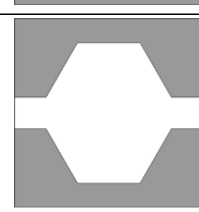


**Trapezoid crimp shape**
Wire-end ferrules + twin wire-end ferrules
0.14 to 240 mm²

**Trapezoid special crimp shape**
10 to 240 mm²
Crimping of ferrules with thinned ("compacted") fine stranded conductors (IEC 60228).



**Hexagonal crimp shape**
Space-saving crimp shape that can produce optimum contact in narrow, round terminal blocks with the same cross-section compared to square crimps.



Insulated ferrule

Twin Ferrule

Uninsulated ferrule

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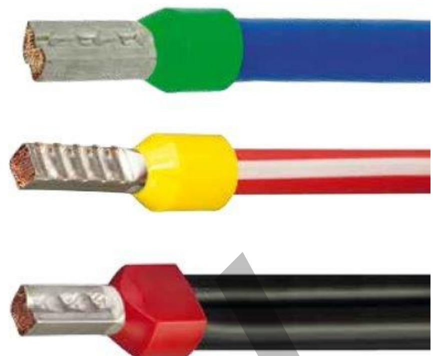
## 11. *Wire End Ferrules*



### 11.1 Basics

The standard for the processing of ferrules is IEC 46228 (= DIN 46228).

Wire end ferrules are used as a joining aid when assembling the ends of the wire (in screw terminals), to protect the individual wire of the conductor and for good contacting in the spring terminal strip.

**Wire end ferrule and clamp connections - Yes or no?**
**A question that is always an issue in everyday practice.**

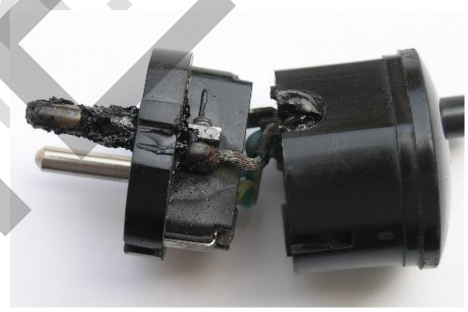
**Standards & clamp connections:** As in many areas of crimping technology, you can only find statements for the use of ferrules that leave some room for interpretation. Standards should essentially be there to provide a clear statement about the "how to"! Statements around clamping technology like: "The connection must be durable and safe" are not really helpful. So, connections are made because "it has always been done that way" or according to the principle "hope: it should work".

Only damage caused by problems of connection variants leads to normative prohibitions. A good example of this is the soldered stranded compound, which, when fixed in a screw terminal, inevitably leads to the failure of the connection! (see also: cold flow). This connection combination, soldering as a substitute for ferrules in screw terminals, is no longer permitted by the VDE 0100-520 standard.

When planning and implementing a connection via a terminal block, it is always important to consult the manufacturer's data sheet. In it, you will find the necessary information about the properties and the correct design of the connection. And in case of doubt? Simply ask the manufacturer! The prerequisite here is, of course, that you also find or have a competent contact person.

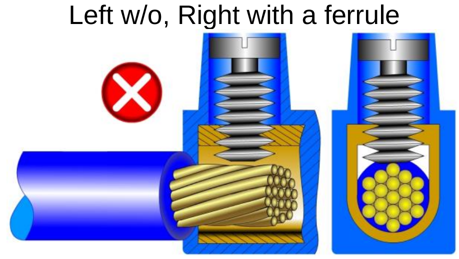
A rule or even a mandatory use of ferrules is not to be found in the known standards. The standard EN60999-1 / VDE 0609 defines all screw connections and also screwless clamp connections (only for copper conductors). In this standard, one finds the information that all mechanical clamp connections, regardless of the clamping principle, must be designed by the manufacturers in such a way that all "unprepared" conductors can be safely connected without "pre-treatment". This applies to the entire variety of conductors offered, from solid one-stranded conductors to flexible fine-stranded wires.

"Unprepared" or "without pretreatment" means: cutting, stripping and mounting the conductor directly in the clamp connection. If a ferrule is crimped onto the stripped conductor beforehand, it is then "prepared" or "pretreated". The standard for terminal blocks (IEC 60947-7-1) states: A manufacturer of a terminal connection must specify a "pre-treatment" of the conductor if this is relevant and therefore important for a safe connection in the terminal.



Defective mains plug caused by a soldered stranded conductor!
Quelle: https://de.wikipedia.org/wiki/Kabelbrand

Spring-cage connection from Phoenix Contact
Left w/o, Right with a ferrule



Screw terminal - operating principle

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## 12. *Turned Contacts – 4/8-Indent Crimp*

### 12.1 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)

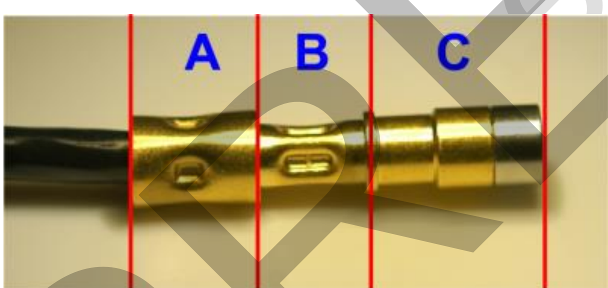
They come in different shapes and sizes and are primarily used where quality requirements are very high, such as in the military, aerospace and medical markets. Applications for the machined contacts range from computer interface connections to flexible production lines in the automotive industry.

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.

### 12.2 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.

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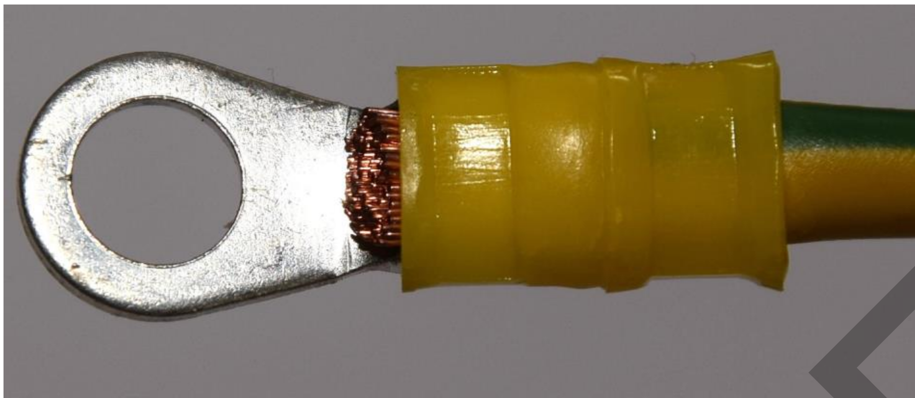
## 13. *Insulated Cable Lugs*

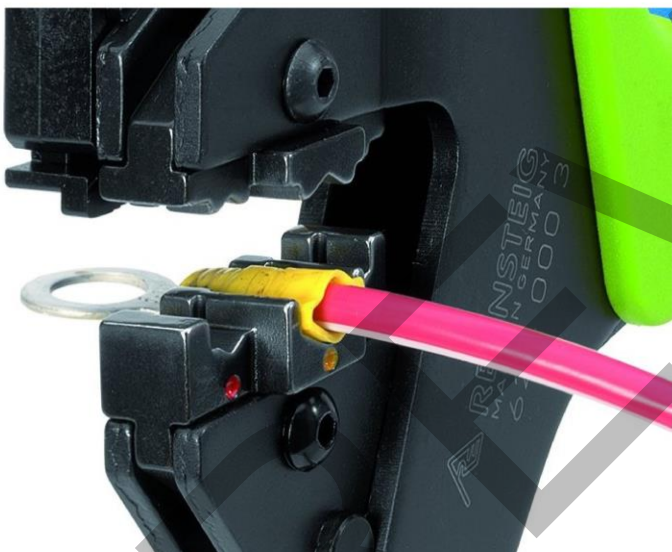

### 13.1 Processing Methods

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



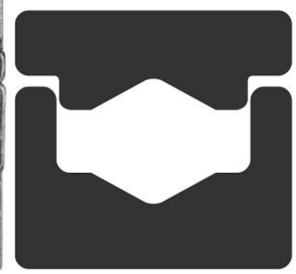
Crimped partially insulated crimp cable lug

### 13.2 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.

### 13.3 Crimp Applicators

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

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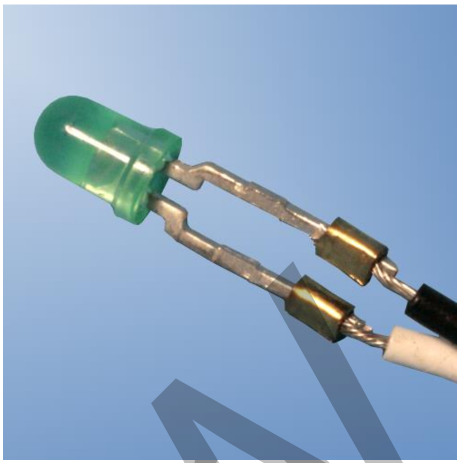


# 15. *SPLICE TECHNOLOGY*

Like many areas in wire processing and crimping technology, splice technology (or splicing) is not regulated by standards. Splice technology is based on the standard (DIN EN 60352) for the processing of open crimp ferrules.

## 15.1 GENERAL INFORMATION

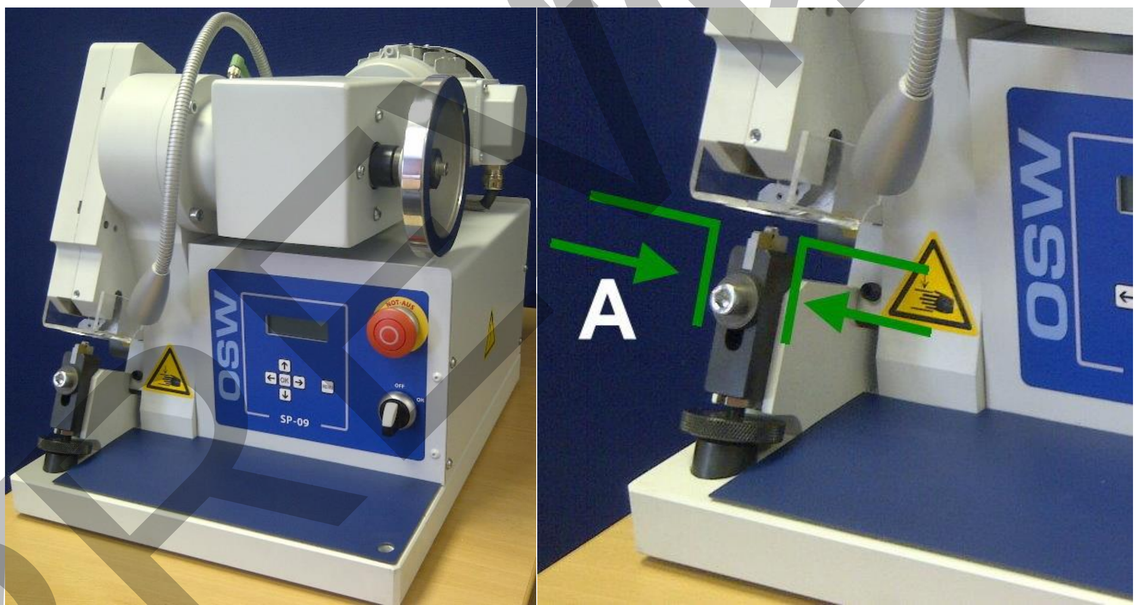
The splice technology is the name for an alternative special form in crimp technology.

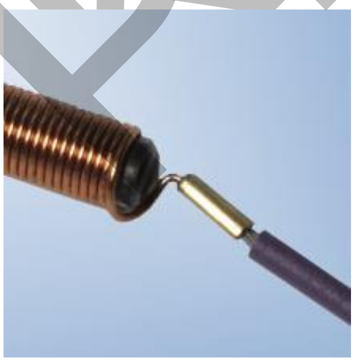
**Important:** Splice technology is not defined by standards! The quality specifications and test methods for splice connections are derived from the standards and applicable manufacturing standards for the open crimp barrel and are supplemented by individual, company-specific manufacturing specifications. Depending on the application and field of use of the splice connection, quality requirements may change or suboptimal connections may be tolerated via special approvals.

The main differences compared to conventional processing of open crimp barrels:

- The crimp contact is cut out of a material strip without waste, preformed and then crimped.
- A splice connection does not have an insulation crimp.
- The width of the spliceband determines the length of the wire crimp area.
- The cross-section range is typically between 0.05 and 6 mm².
- Due to the design of the splice machine, it is possible to process very short connections (wire lengths).

## 15.2 THE SPLICE MACHINE



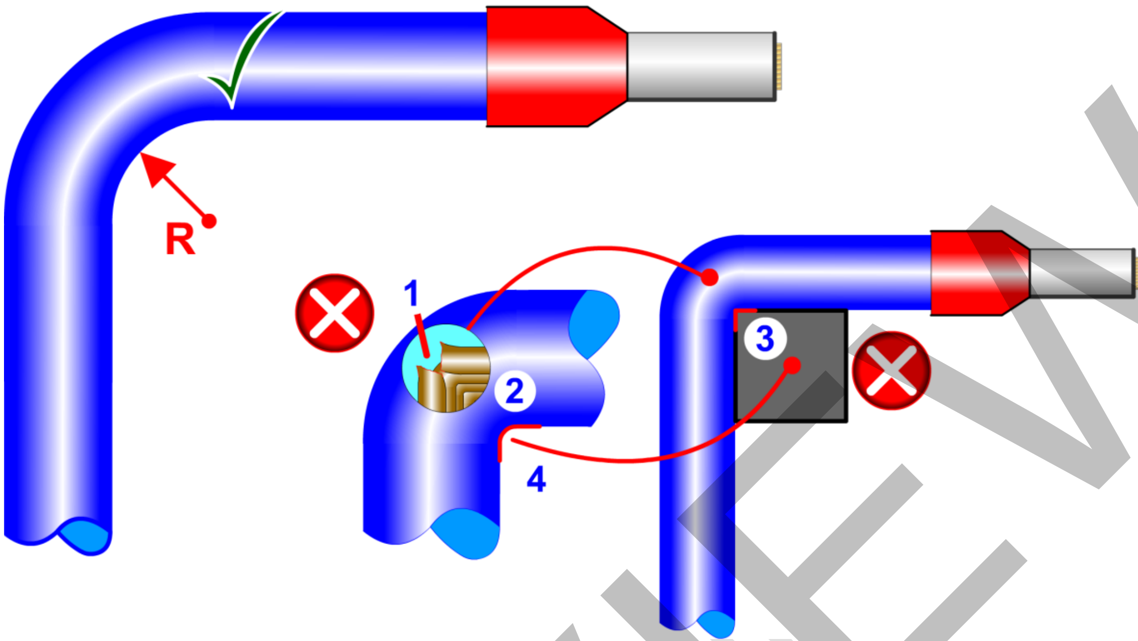



The design of the splice machine offers a operating range (A) in which very short connections can be processed. This is the great advantage of the splice technology with which electrical components can be connected with stranded conductors.

Fig. left: The very short connection of this coil can be optimally connected to the stripped stranded conductor with a splice machine. With classic crimping applicators and the use of open crimp barrels, such short connections simply couldn't be realized.

# 16. *Assembly – Disassembly of Crimp Contacts*

## 16.1 Installing Wires

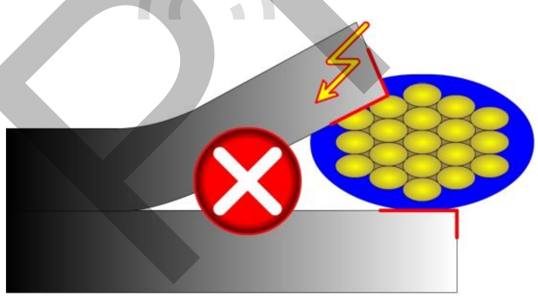



Min. bending radius R = 2 X cable diameter

**Important:** Do NOT bend wires directly after the crimping area. The rule of thumb for bending radii when laying wires: 2 X the diameter of the wire = the smallest permissible bending radius.

**Important:** The wire must NOT be:
1. be bent narrower than the bending radius. The single wires inside (2) are compressed, while the single wires outside (1) are stretched and break off.

2. be routed around sharp-edged corners (3). In addition to tearing off individual wires (see 1), there is a risk here that the insulation may be worn through due to vibration, for example (4). Use cable ducts, corrugated tubes, edge protectors, etc. to protect the wire when drilling holes!



To avoid damage to the wires, do NOT mechanically clamp them between fixed structural, body or housing parts during installation!

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# 17. *Crimping Technology – Procedural Information*

## 17.1 Foreword & Notes

The processing of open crimp ferrules is defined by DIN EN 60352-2. However, these specifications are very general and define only a relatively small part of the current standard in crimping technology. These insufficient definitions in the standard lead to discussions time and again, especially in the case of crimp connection failures or claims. The fact is: crimp connections that "only" meet the requirements of DIN EN 60352-2 are very often not up to the actual, real requirements in today's practice.

Today's standards are defined by the very detailed factory standards of the major industrial sectors. The specifications are described down to the smallest detail in accordance with the subsequent area of application of the crimp connection. Advantage: Behind all these additional specifications to the DIN EN standard, there is always a technical justification. Resulting from experience and failures from the past. The quality and therefore also the durability of the crimp connection is thus constantly increased and improved many times over in comparison to the "DIN EN standard".

The present processing information forms the basis for the evaluation of crimp connections by Kabelforum and can also be the basis for an internal company standard or a supplier specification. This processing information can also be used as a validation procedure for crimping tools.

Please note that the processing specifications of your customer are primarily decisive for your production and testing. In case of doubt, you should have a discussion with your customer and clarify the corresponding quality specifications.

In addition to the standards, you can expand your quality specifications as you wish within the framework described here. This depends on your company's understanding of quality and, of course, on your willingness to invest. Fully automatic machines, with the appropriate monitoring modules, deliver the best quality, but also at a considerable price. Ultimately, the application decides which quality specifications are mandatory.

**Important:** A factory standard or supplier specification always covers 2 basic areas:

- **General quality specifications** for cable processing and crimping technology.
  This defines the basic specifications around wire processing and crimp connections.
- **Application-specific quality specifications.**
  Depending on the crimp connection, specifications deviating from the standard are defined. In most cases, this concerns the micrograph evaluation and can lead to a special release in the case of suboptimal crimp connections.

**Important:** Depending on the application of the crimp connection, quality specifications may change. This is especially true if the assignments of the nominal cross-section of the wire to the crimp contact do not fit. In this case, the possible mechanical and electrical load on the crimp connection in use determines which compromises in quality are possible.

**Important:** The procedures and rules of this documentation also apply to the use of hand tools. Even if suboptimal quality is to be expected as a result of the use of these tools.
**If the work steps performed with hand tools do not meet the required quality specifications, they must not be used!**

These processing guidelines are a collection of information from standards (including factory standards), processing specifications or the result of practical tests and empirical values and do not claim to be complete. All information is without guarantee and does not relieve the user of his own responsibility and duty of care with regard to his applications! The technical background for the individual specifications can be found in the corresponding chapters in the reference book: "Fundamentals of Crimping Technology".

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