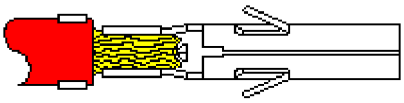
Good Crimps and How to Recognize Them



Introduction

You've made it through all the connector catalogs, found the connector that meets all your design criteria and is just right for your application. With the right current rating, voltage rating, circuit size, engagement force, wire AWG capabilities, configurations, termination method and safety features, e.g. positive locks, fully-isolated contacts, polarization and agency certifications, it is, in short, the perfect connector.

But don't let out a huge sigh of relief quite yet --especially if the connector you've chosen uses a crimp termination system. While this can be one of the fastest, most reliable and rugged termination methods, if the terminal isn't crimped onto the wire correctly you can forget all about the hard work you put into selecting the right connector. And, although there are 13 common crimping problems that can reduce the reliability of your product, these problems are easy for you to avoid with a little knowledge and advance planning.

To begin with, it helps to understand that a terminal has three major sections: Mating, Transition and Crimping **(Illustration A)**. The Mating section, as the name implies, is the section of the terminal that mates, or becomes the interface, with the other half of the connection. This section was designed to mate with a terminal of the opposite gender and to perform in a certain manner by the connector design engineer. Anything that you do that deforms the Mating Section, especially during the crimping process, will only reduce the connector's performance.

The Transition Section also is designed so that it would not be affected by the crimping process. Here again, anything you do that changes the position of the Locking Tangs or Terminal Stop affects the connector's performance.

The Crimp Section is the only section that the crimping process is designed to affect. Using termination equipment recommended by the connector manufacturer, the crimp section is deformed so it can be securely attached to a wire. Ideally, all the work that you do to crimp a terminal onto a wire occurs only in the Crimp Section.

An example of a properly performed crimp is seen in Illustration B. Here, the insulation crimp compresses the insulation without piercing. The wire strands (or brush) protrude through the front of the conductor crimp section by at least the diameter of the wire's conductor. For example, an 18 AWG wire would protrude at least .040". Both the insulation and conductor are visible in the area between the insulation and the conductor Crimp Section. The conductor Crimp Section shows a bellmouth shape in the leading and trailing ends, while the Transition and Mating Sections remain exactly the same as they were before the crimping process.

If your crimped terminal does not look like the terminal in **Illustration B** - the problem may have been caused by something that went wrong during the crimping process. Here are 13 of the most common problems that may occur during the crimping process and what you can do to avoid them.

1. Crimp Height is Too Small

The crimp height, which is the cross sectional height of the conductor Crimp Section after it has been crimped, is the most important characteristic of a good crimp. The connector manufacturer provides the crimp height for each wire size for which the terminal was designed. The correct crimp height range or tolerance for a given wire may be as small as 0.002". With a specification this tight, verifying that the press is setup correctly is very important for achieving a good crimp.

A crimp height that is either too small **(Figure I)** or too large **(Figure II)** will not provide the specified crimp strength (terminal retention to the wire), will reduce the wire pull out force and current rating, and may generally cause the crimp to under perform in otherwise normal operating conditions. A crimp height that is too small also may cut strands of the wire or fracture the metal of the conductor crimp section.

2. Crimp Height Too Large

A crimp height that is too large will not compress the wire strands properly, causing excessive voids in the Crimp Section because there is not enough metal-to-metal contact between the wire strands and the metal of the terminal.

The solution to problems #1 & #2 is very simple: adjust the conductor crimp height on the crimp press. Using a caliper or micrometer as shown in **Illustration B**, verify that the crimp height is within specification when the press is first used for a production run and recheck it as frequently as necessary during the run to maintain the proper crimp height.

3. & 4. Insulation Crimp Too Small or Too Large (Figure III and Figure IV)

Connector manufacturers do not typically supply a crimp height for the insulation due to the variety of insulation types and thicknesses. The insulation crimp provides a strain relief for the conductor Crimp Section so that as the wire flexes, the wire strands do not break. An insulation crimp section that is too small may overstress the metal in the insulation Crimp Section, weakening the strain relief function.

Most types of crimp tooling allow the insulation crimp height to be adjusted independently of the conductor crimp height. The correct adjustment allows the terminal to grip the insulation for at least 180 degrees without piercing the insulation. An insulation displacement, or compression where the OD of the terminal's insulation crimp and the OD of the insulation are approximately the same, is ideal.

5. Loose Wire Strands

Loose wire strands **(Figure V)** are another common cause of crimping problems. If all the wire strands are not fully enclosed in the conductor Crimp Section, both the strength of the crimp and the current carrying capability may be greatly reduced. To get a good crimp you need to meet the crimp height the connector manufacturer specifies. If all the strands are not contributing to that crimp height and therefore, crimp strength, then the crimp will not perform to specifications. Generally, the problem of loose wire strands is very easy to solve by simply gathering the wires back into a bunch before inserting them into the terminal to be crimped. The strands may have been inadvertently separated during the handling or bundling process if stripping the insulation from the wire is done as a separate operation. Using a "strip and retain" process for insulaton removal, where the insulation slug is not completely removed from the wire until it is ready to have a terminal crimped onto the wire, helps minimize the problem.

6. Too Short Strip Length

If the strip length is too short or if a wire is not fully inserted into the conductor Crimp Section, the termination may not meet the specified pull force because the metal-to-metal contact between the wire and the terminal is reduced. As shown in **Figure VI**, the strip length of the wire is too short (note that the insulation is in its proper position), not allowing the required one wire OD extension in front of the conductor Crimp Section. The solution is simple: increase the strip length of the wire stripping equipment to that specified for that specific terminal.

7. Wire Inserted Too Far

Another crimping problem that relates to a too short strip length occurs when the wire is inserted too far into the crimp sections. As **Figure VII** shows, the insulation is too far forward of the insulation Crimp Section and the conductors protrude into the Transition Section. This may cause as many as three failure modes in the actual application. Two relate to a reduced current rating/wire pull out force due to a reduction of the metal-to- metal contact in the conductor Crimp Section. A metal-to-plastic contact isn't as strong, nor does it conduct electricity, as well as metal-to-metal.

The third failure mode may occur when the connectors are mated. If the wire protrudes so far into the Transition Section that the tip of the male terminal hits against the wire, it may prevent the connectors from fully seating or it may bend the male or female terminals. This condition is known as "terminal butting".

Under extreme cases, the terminal may be pushed out the back of the housing even though it was fully seated in the housing. To solve this problem, make certain the wire is not inserted into the press with so much force that it overcomes the wire stop on the press, or adjust the position of the wire stop so that it correctly axially positions the stripped wire.

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8. "Banana" (Excessive Bending) Terminal

One of the most descriptive crimping problems is known as a "banana" crimp **(Figure VIII)**, because the crimped terminal takes on a banana shape. This makes it difficult to insert the terminal into the housing and may cause terminal butting. This problem is easy to solve by adjusting the position of the hold down pin on the crimp press. This small pin is located in the crimp press and contacts the terminal in the mating section while the crimp sections are being crimped onto the wire. During crimping, a significant amount of metal on one end of the terminal (in the crimp section) moves. These high forces tend to force the front of the terminal upwards, unless it is held down by the aptly-named "holddown pin".

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9. Crimp Too Far Forward

One of the more obvious crimping problems is when part of the Transition Section is damaged, as shown in **Figure IX**. In the terminal shown, the tab sticking up is a design feature called a "terminal stop". Its function is to prevent the terminal from being inserted too deeply into the housing. If the stop is extremely damaged, the terminal can actually be pushed all the way through the housing.

The solution is relatively simple. What causes the problem is that the terminal and carrier strip (the band or strip of metal the terminals are attached to when you receive them from the manufacturer) is not properly located with respect to the press. To solve it, simply loosen the base plate of the interchangeable tooling and realign it to the press.

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10. Undersized Bellmouth

The correct size for a bellmouth **(Figure X)** is approximately 2X the thickness of the terminal material. For example if the terminal is made from material that is .008" thick, the bellmouth should be approximately .016". While a few thousands of an inch either way will not materially affect the terminal's performance, if the bellmouth is missing or if it is less than one material thickness, there is a risk of cutting the wire strands. The fewer strands that remain, the lower the termination strength. To correct the problem, make sure the punch and anvil on the crimping equipment are properly aligned.

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11. Oversized Bellmouth

There is also a problem if the bellmouth is oversized **(Figure XI)**, because this reduces the total area that the crimp section of the terminal has in contact with the wire. The less the wire-to-terminal interface, the lower the wire pull out force. If the crimp height is correct, then it is likely the problem is caused by worn tooling, which should be replaced.

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12. Carrier Cut-off Too Long

The carrier strip is cut off of the terminal during the crimping process. If the remaining cutoff is too long **(Figure XII)**, problems can occur. The extra metal may protrude out the rear of the connector when the terminal is inserted into the housing, causing the connector to arc between adjacent contacts when higher voltages are applied. If the carrier cutoff at the front of the terminal is too long, the extra length may interfere with connector mating and result in "terminal butting".

The solution is fairly simple. Adjust the baseplate on the press so the terminal is centered properly in the crimp press. Another indication that the terminal is not centered correctly is that the bellmouth isn't properly former either. This occours because the tooling for the bellmouth and the carrier cutoff are spatially related.

13. Bent Lock Tangs

Although bent lock tangs are not necessarily the result of a poor crimping process, the connector can fail just the same. Lock tangs (**Figure XIII** may be bent either in or out too far, which impacts the terminal's ability to completely lock into the shelf in the housing that was designed for this purpose. The tangs may be damaged as the terminals are unwound from the reel if the friction wheel on the reel holder of the crimp press is too tight or it can be caused by handling after the terminals are crimped onto the wires. Typically, terminated wires are gathered into a bundle and inventoried or transported to another location in the plant. During the bundling, or as each terminated wire is removed from the bundle, the locking tangs may be bent.

If the damage is occurring at the crimping press, then the friction wheel needs to be adjusted so it is only tight enough to keep the reel of terminals from being unwound by their own weight. If the problem is occurring during the bundling process, smaller bundles or improved handling procedures need to be implemented.

Rules

While there are 13 problems that may be caused during the crimping process, there are just four simple rules that will help ensure a successful connector application:

1.Choose the right connector for your application requirements.

2. Use the crimp tooling specified by the terminal manufacturer.

3. Properly adjust and maintain the crimp tooling in good working order.

4. Periodically replace the parts that displace metal (e.g. conductor and insulation punches, anvils and terminal cutters).


Since most of the problems that are reported to connector manufacturers relate to one of these thirteen crimping problems, Molex offers an easy-to-use guide to help you avoid problems or recognize them quickly enough so that you make only good crimps. To order this guide contact Molex Incorporated, 2222 Wellington Court, Lisle, Illinois 60532, Attention: Good Crimp Drawings.

**The parts of the crimp tooling that significantly displace the metal of the terminal - the conductor and insulation punch, anvils and the terminal cutoff tooling will need to be periodically replaced.*