DVD-58C
Introduction to Wire Crimping

Below is a copy of the narration for DVD-58C. The contents for this script were developed by a review group of industry experts and were based on the best available knowledge at the time of development. The narration may be helpful for translation and technical reference.

Welcome to the world of crimping technology. Crimping is a way of connecting terminals or contacts to wires - as well as wires to wires. Crimping was developed as an alternate technology to soldering terminals.

The solderless terminal was created in the 1930s.The earliest crimping tools were little more than modified pliers. The first large-scale application of crimping was in aircraft manufacturing. These solderless connections later appeared in televisions, computers, cars and all major appliances.

Today, crimping is used in nearly all of our most sophisticated products. In fact, crimping has become the dominant terminating technology.

This program will provide you with an overview of wire crimping. We'll begin by discussing some of the advantages of crimping. Then you'll be introduced to the three key elements in the crimping process: the wire, the terminal and the crimping tool.

Of course, there's a fourth element - no doubt the most important. That's you - the trained operator doing the crimping.

From there, we'll examine the processes for manual crimping, semi-automatic crimping and fully automatic crimping. Finally, you'll be given the criteria and methods to evaluate acceptable and unacceptable crimps.

Let's take a look at some of the reasons companies crimp terminals to wires. The amount of time needed to train a person to properly crimp is much less than what's required for other types of termination processes.

Slight oxidation or corrosion of wires and components can make soldering difficult -- or even impossible -- by preventing the solder from making contact with the metal surface. However, this isn't a problem in crimping. That's because the force of the crimping action breaks through any surface oxidation, allowing the metal surfaces to make contact with one another.

Crimping can be performed in conditions that prohibit soldering. For example, electricity may not be needed to operate manual crimping tools. This makes field repairs easier.

Once the crimping process is set up and verified, inspection takes very little time. As you can see, crimping is a relatively simple operation. It's easy to maintain a clean workstation and there are virtually no safety issues.

Now that we've taken a look at the positive features of crimping, let's examine the three key elements in the crimping process. Remember that there's the wire, the terminal or contact, and the crimping tool.

There are two basic types of wire - solid and stranded. For the purpose of this program, we'll be using stranded wire since it's more common.

There are two different functions performed by wires. Power wires carry power supply voltages. They distribute operating power within an electronic product. Signal wires are generally smaller than power wires. They carry the lower voltage signals that control the functional operation of a product, or provide data input and output.

Wires may be of various gauges, or diameters. They may be coaxial cable, ribbon cable, or twisted shielded wire, depending on how they're used. Wire AWG, or American Wire Gauge specifies size. AWG is a reverse number system where the larger numbers refer to the smaller wires. In other words, an 18 AWG wire is smaller than a 14 AWG wire.

Wire strands are usually copper or plated copper. It's important to realize the wire stranding and insulation type can vary within one wire size. The wire stranding, or conductor carries the electrical current. The insulation keeps the conductor wire from coming into contact with other conductive components or surfaces.

Wire insulation may be made of various materials such as Teflon, rubber or PVC - and may be different colors for identification purposes. Also, the insulation material, thickness and hardness tend to vary based on how and where the wire is used.

The second element in wire crimping is the terminal or contact. Terminals come in a variety of forms - the most common being ring and spade. Even though the front end of the terminal may differ depending on the application, the crimp, or barrel sections of these terminals remain constant.

For most applications, it's not economically practical for connector manufacturers' terminals to accept only one wire size, wire stranding or insulation diameter. Therefore, most terminals accommodate several wire sizes, stranding and a range of insulation diameters. In other words, the terminals are designed to meet acceptable crimping standards over a specific range of wire sizes.

Terminals are either uninsulated or insulated. Uninsulated terminals are most often used in commercial applications where insulation clearance is not a design issue. This means there isn't a concern for the terminal touching, or short-circuiting to something else.

Insulated terminals are mostly used in applications where it is desirable to keep conductor exposure to a minimum. This will keep components that are close to the terminal from shorting out to the terminal.

There are generally two types of terminals - open barrel and closed barrel. Open barrel terminals are often uninsulated. There are usually two "U-shaped" areas - one to crimp the wire conductor and one to crimp the wire insulation. The insulation crimp acts as a strain relief. In other words, whenever the wire is moved, the crimp on the insulation keeps the strain from being felt at the conductor crimp area.

Closed barrel terminals are usually insulated. There is an "O-shaped" or closed area where the wire is inserted.

Now, let's look at some common contacts. Contacts are almost always uninsulated. Although there are many different contacts to choose from, there are two basic types - machined and stamped. The crimping concept, however, is similar for both.

The machined contact may have an area for the wire insulation to fit into, but in many instances the wire insulation abuts the rear of the contact. Even though the wire insulation will not be crimped, it's important that it goes into the contact.

Many stamped contacts have an insulation support section. When this is provided, it's necessary that the wire insulation be retained in this section. The insulation support section of the stamped contact will most often be crimped. It is required that the insulation be within the crimp area.

At this point we've discussed the wire and the terminal or contact. Before we move on to our last element, the crimping tool, let's examine a very important subject regarding the wire and the terminal - the strip length of the wire.

It's important to realize that one strip length doesn't fit all terminals and contacts. Strip length is important because it provides a good conductor and insulation fit to the terminal. A good strip also offers strain relief for vibration protection in the field.

For proper crimping, terminal manufacturers supply spec sheets so that the terminal is properly applied to the wire. Strip length is an important factor.

There are numerous methods of stripping wire. For jobs that have any volume, it is helpful to have the wire processed through automated equipment. These machines will cut the wire to the correct length and also strip the ends as required.

There are also times when it is appropriate to strip the wire manually. Acceptable tools include rotary strippers, hand mechanical strippers and thermal strippers. There are also unacceptable tools.

A good strip should consist of a clean, straight strip off the insulation. There should be no broken, bent or otherwise damaged strands.

Now, let's turn our attention to the crimping tool. When it comes to selecting a crimping tool, the most important question is: what would be the best tool for what needs to be accomplished?

In other words, does the application require hand stripping and the use of a manual crimper because of low volume? Or is there sufficient volume to warrant a fully automatic wire process crimper? Crimping with a manual hand tool, semi-automatic press and die, or fully automatic wire processor all involve different levels of variability. Each element of the crimping process will affect the quality of the completed terminations. Let's stop for a moment and review the material we just covered.

Manual crimping involves the use of hand crimpers and involves the least set-up. This method of crimping is desirable when crimping small quantities of terminals, or when air is not available for the pneumatic crimpers to be set-up.

The hand crimping tools may have dies that are part of the tool, or dies that are interchangeable. It's important to select the proper crimper and proper die for a given job.

Let's take a look at the hand-crimping tool more closely. The crimping portion of the tool consists of a nest, which holds the barrel of the terminal to be crimped - and an indenter, which actually does the crimping.

One decision that's usually required is to choose the correct crimper opening for the gauge of wire to be crimped

Hand crimping tools should be calibrated at regular intervals. These tools are usually calibrated using gauge pins to measure the distance between the crimping heads or indenters - depending on the type of tool being calibrated. Make sure the crimping tool you're using has a calibration sticker.

Once calibrated, it's important to make at least five sample crimps and to perform pull tests on these samples. This verifies the repeatability of the tool. We'll discuss pull tests later in this section.

As you can see, there really aren't any adjustments to make on a hand-crimping tool. If the tool doesn't measure properly, it is no longer acceptable for use until the crimping dies are repaired or replaced.

In order to maintain uniform crimp terminations, most hand crimpers have a ratcheting mechanism that prevents the tool from releasing until the crimp has been completed. During calibration, this ratcheting mechanism is also checked for reliability - and adjusted if necessary.

Now that you've been introduced to the manual crimping tools, let's examine how you'll do your job. We'll begin with your workstation. It's important to maintain a clean and organized workstation. This can make it much easier to do your work.

The materials you'll use will depend on the job you're doing, and are specified on the assembly drawing or other company documents. These materials include the wire or wires; the terminals or contacts; connectors; and the crimping tool or tools. These materials should be organized at your workstation so you can do the job in the most comfortable, efficient manner.

When the job is completed, the materials should be returned to the stockroom. At that point you can obtain the materials for the next job.

Now, let's take a close look at how a typical crimping job is performed. The first step is to make sure the crimping tool is working properly. We start by pre-loading the terminal barrel into the crimper nest. The wire is now positioned in the terminal barrel. Finally, the handles are closed to complete the crimp. Because of the ratcheting mechanism, most crimpers will not release until the crimper is fully closed.

One method of checking if the crimper setting is accurate is a bend test. Bend testing is used to verify the insulation support crimp. This crimp should hold the insulation as firmly as possible without cutting through to the conductor strands. We make the crimp on unstripped wire. To perform the bend test, grip the wire about three inches from the termination and bend the wire ninety degrees in one direction, then ninety degrees in the opposite direction. If the wire pops out, the crimp is too loose and the hand crimper setting should be changed.

After passing a bend test, it's important to pull the wire out of the termination and visually inspect the insulation. A proper crimp should hold the insulation firmly without cutting it.

In most companies, a specific number of sample conductor crimps are made before production can begin. These crimps are made without the insulation crimp so they can be pull tested.

Pull testing is one method of verifying the reliability of the conductor crimp. Another method is to measure the crimp height. If crimp height is to be measured, it should be done prior to pull testing since pull testing is a destructive test.

Crimp height is measured with a micrometer to verify acceptable conductor crimps. Crimp height is measured from the top surface of the formed crimp to the bottom most radial surface. This measurement should match the crimp dimension specified for the particular tool, wire and terminal. If the measurement doesn't conform, it means the crimping tool needs to be fixed. Any samples that fail crimp height measurement are not pull tested. Crimp height data is often collected for process control - in SPC logs.

Pull testing is the second method of verifying the reliability of the conductor crimp. During pull testing, the terminal and the wire are pulled until the termination pulls apart, or the wire breaks. Since pull testing is a destructive test, it is only performed on these initial set-up samples. The pull rate is generally one inch per minute. When the test is completed, the force taken to pull the crimp apart - usually displayed in pounds - is compared to the appropriate chart to see if it's acceptable. Many companies perform pull testing whenever there's a change in tooling or operators.

Once the integrity of the crimp is verified, production begins. When utilizing hand crimping, or semiautomatic crimping, each crimp should also be visually inspected. If crimping is being done with fully automatic equipment, a sampling plan will be necessary.

The preferred crimp for this insulated closed barrel terminal will look like this. The barrel crimping indent is well formed and properly positioned. The wire insulation grip impression is well formed and provides proper support without crushing the insulation. In addition, the end of the bare conductor should protrude through the wire crimp barrel an acceptable minimum and maximum distance based on your company's workmanship standards. Each terminal manufacturer will have specifications on crimp quality.

Let's look at why we might reject a crimp. In this case, the barrel crimping indent is only partially located over the lug barrel. This means the terminal was not fully inserted into the crimp jaws.

This is an indication that incorrect crimp tool jaws were used, or that insufficient pressure was applied.

In this case, the wire insulation grip pressure is insufficient to provide proper gripping of the insulation. Conversely, this insulation is crushed from too much pressure.

In addition, the crimp is rejected when the bare conductor protrudes through the crimp barrel in excess of your company's workmanship standards; or when there's insufficient conductor protrusion. Section 4 will explain crimp evaluation criteria in greater detail. Let's stop once again to review the material we just covered. Section 3 resumes on the second tape.

Now let's turn our attention to semiautomatic and fully automatic crimpers. Powered crimpers operate with air or electricity, and are usually dedicated for a particular application - such as crimping contacts for a specific connector.

These crimpers utilize either interchangeable heads; or interchangeable dies. Sometimes the interchangeable part is called an applicator which contains the dies and stripper blades.

Like the manual crimpers, the powered crimpers have a nest that holds the barrel of the contact and an indenter that makes the crimp. A foot pedal activates the semi automatic machines. Many of these machines utilize air pressure to perform the crimping action. Some fully automatic machines utilize an electric motor only, while others use air pressure in conjunction with the electric motor.

The terminals to be crimped by these machines come on tape and reel. The reel is loaded onto the crimping machine and the tape is properly threaded. The tape is then advanced into the crimping section where an applicator picks up and places the terminal in the crimper nest.

There are two basic types of semiautomatic machines. One requires that the wire be stripped before placing it in the barrel of the terminal. The second type will strip the wire as part of the crimping process. When the foot pedal is pressed the crimping or stripper/crimper operation will take place.

Now let's look at the differences in the fully- automatic crimping machine. Wire is fed in from a barrel or from a spool. The wire is automatically measured - then cut and stripped to pre-programmable lengths.

Simultaneously, the terminal is placed in the crimper nest by the applicator. The cut and stripped wire is then positioned in the termination area and the crimp occurs automatically.

Once the automatic crimping machines are properly setup, operation is fully automatic. In terms of monitoring, you just have to make sure there is a sufficient supply of wire and reeled terminals - and to replenish them when required.

At this point, let's take a look at some typical set-up procedures. Different machines require different set-ups. You'll be trained to set up and operate the specific equipment used by your company. This part of the video should help you understand what's involved.

We'll start with a semiautomatic machine. The first step is to install the correct applicator. This should be specified in the assembly documentation. Make sure that the power is disconnected and that the tooling is clean and not worn.

The terminals are now loaded onto the machine. They should be advanced into the tooling so that the first terminal is located over the anvil. Then manually cycle the machine so that a complete cycle can be made without interference.

The next step is to verify the tooling alignment by checking the impression on the bottom of the crimp that was made by the anvil tooling. Also, check that the terminal feeder locates the next terminal over the center of the anvil tooling. You may have to make some adjustments during this set-up procedure to make sure the machine is working properly.

Once the semiautomatic machine is correctly set-up, reinstall the safety guards. Then turn on the power. At this point you'll crimp some sample terminations. These should be visually inspected. You'll be evaluating crimp parameters that will be described in the next section of the tape.

As with manual crimping, crimp height measurement may be done on sample crimps. In addition, pull testing will be performed to verify the conductor crimp. When all these tests pass, production can begin.

Now, let's watch the set-up on a newer fully automatic wire-processing machine. Again, the correct applicator must be installed for the job being run, and the proper terminals. Also, the correct wire will be pulled through the pre-feeder from barrel or reel processor.

These types of machines are microprocessor controlled - meaning that the operator enters parameters for the job. This includes cut and strip lengths, and feed rates for both wire and terminal. Crimp height is adjusted manually - or automatically. Again, samples should be made and verified through pull testing.

Many of these sophisticated machines have quality control systems, which automatically measure crimp height and verify other key parameters. As we said earlier, once production begins these machines do everything automatically. Let's stop for a moment and review the information we just covered.

This final section will explain crimping criteria for evaluating both open and closed barrel crimps. You'll learn to recognize preferred, acceptable and unacceptable crimps.

We'll begin by taking a look at the anatomy of a crimp. This is an illustration of an open barrel crimp. Remember, on open barrel terminations there are two U-shaped areas - one that terminates the conductor and one that terminates the insulation.

Let's examine the parts of our crimp more closely. The conductor crimp is the mechanical compression of the metal terminal around the metallic wire conductor. This creates a continuous conductive electrical path.

The conductor crimp height is measured from the top surface of the formed crimp to the bottom most radial surface.

The bellmouth is the flare that's formed on the edge of the conductor crimp and acts as a funnel for the wire strands. This funnel reduces the possibility that a sharp edge on the crimp will cut or nick the wire strands.

The conductor brush is made up of the wire strands that extend past the conductor crimp on the contact side of the termination. This is done so that mechanical compression occurs over the full length of the conductor crimp. The conductor brush shouldn't extend into the contact area.

Now, let's look at the insulation portion of the crimp. The insulation crimp, or strain relief, is the part of the termination that provides wire support for insertion into the connector housing, and allows the termination to better withstand shock and vibration. The crimp needs to hold the insulation as firmly as possible without cutting through to the conductor strands.

The insulation crimp height is based on the insulation thickness and hardness and is usually not tested. Insulation position is the location of the insulation in relation to the transition area between the conductor and insulation crimps. The insulation position is such that the insulation is crimped along the full length of the insulation crimp so that no insulation gets crimped under the conductor crimp.

Now that we've examined the features of an open barrel crimp, let's look at the criteria for a preferred crimp.

The wire strands should be visible at the contact end of the wire barrel. All wire strands should be inside the crimped wire barrel with the seam closed. A bellmouth should be visible at the wire entry end of the wire barrel. And both wire strands and insulation should be visible between the conductor crimp and the insulation crimp.

The closed barrel termination is a less complex connection than the open barrel terminal. There is simply an O-shaped or closed area where the wire is inserted.

Let's examine the things to look for in a preferred crimp. Wire strands must be visible at the contact end of the wire barrel. A bellmouth must also be visible at the contact end of the wire barrel - and the barrel crimping indent should be well formed and properly positioned. The wire insulation must be inside and supported by the insulation support barrel. The wire insulation grip impression should be well formed and provide proper support without crushing the insulation.

Now that you've been introduced to the criteria for preferred crimps for both open and closed barrel terminations, let's examine more crimps to understand how to evaluate whether they're acceptable or unacceptable.

We'll conclude our evaluation section by discussing some common problems that may occur during the crimping process - and explain how to avoid them.

The first problem characteristic we'll examine is improper crimp height. Crimp height is probably the most important characteristic of a good crimp. A crimp height that's either too small or too large won't provide the specified crimp strength, will reduce the wire pull out force and current rating, and may cause the crimp to generally under- perform in otherwise normal operating conditions.

A crimp height that's too small may cut strands of wire, or fracture the metal of the conductor crimp section. In addition, a crimp height that's too small reduces the current carrying capability of the crimp.

A crimp height that's too large won't compress the wire strands properly. The result is excessive voids in the crimp section - meaning there will be a lack of contact between the wire strands and the metal of the terminal. In addition, a loose crimp will oxidize over time and eventually cause an electrical failure.

The solution to crimp height problems is easy. Simply adjust the conductor crimp height on the crimp press, make new samples and re-check the crimp height.

Another problem occurs when the insulation crimp is too small or too large. Remember that the insulation crimp provides a strain relief for the conductor crimp section so that as the wire flexes, the wire strands don't break. If the insulation crimp height is too large, there won't be sufficient strain relief. If the insulation crimp height is too small, it may overstress and weaken the metal in the insulation crimp section.

Some 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.

Loose wire strands is another common cause of crimping problems. If all the wire strands aren't fully enclosed in the conductor crimp section, both the strength of the crimp and its electrical current carrying capability may be greatly reduced. The loose strands may also cause a short circuit, or may arc to a nearby contact. To solve this problem, gather the wires back into a bunch before inserting them into the terminal.

If the strip length is too short, or if the wire isn't 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. To solve the problem, simply increase the strip length.

Another crimping problem that relates to a short strip length occurs when the wire is inserted too far forward into the crimp sections. What happens is the insulation is too far forward in the insulation crimp section and conductors protrude into the transition section. Since there is reduced metal-to-metal contact there may be a reduced current carrying capacity and/or wire pull out force.

To solve this problem, the wire must not be inserted into the press with so much force that it overcomes the wire stop on the press. The wire stop may also need to be adjusted so that it places the stripped wire into the correct position.

When there is excessive bending of a termination, this is called a "banana" terminal. Excessive bending is caused when the hold down pin on the crimp press isn't adjusted properly. A banana terminal will be difficult to insert in a connector housing.

The last problem we'll discuss is an undersized or oversized bellmouth. The correct size for a bellmouth is about twice the thickness of the terminal material.

If the bellmouth is undersized, there is a possibility that the wire strands may be cut. To correct the problem, make sure that the tooling is properly aligned.

If the bellmouth is oversized, the total contact area between the crimp section of the terminal and the wire will be reduced - thereby reducing the pull force. If the crimp height is correct, the likely cause of the problem is worn tooling.

This program has provided an introduction to the wire crimping operation. First, we discussed the advantages of crimping versus soldering. Then you were introduced to the three elements in the crimping process - the wire, the terminal and the crimping tool.

We continued by examining the processes involved with manual crimping. Then we discussed typical set-up and operation of both semiautomatic crimping machines and fully-automatic wire processors. We concluded with the criteria and methods for evaluating acceptable and unacceptable crimps.

The quality of a single termination can affect the operation of an entire electronic product. Careful attention to every detail of your job will help to ensure that these products work properly and reliably.