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Application Note

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The Importance of Proper Crimping in Fiber Optic Assemblies

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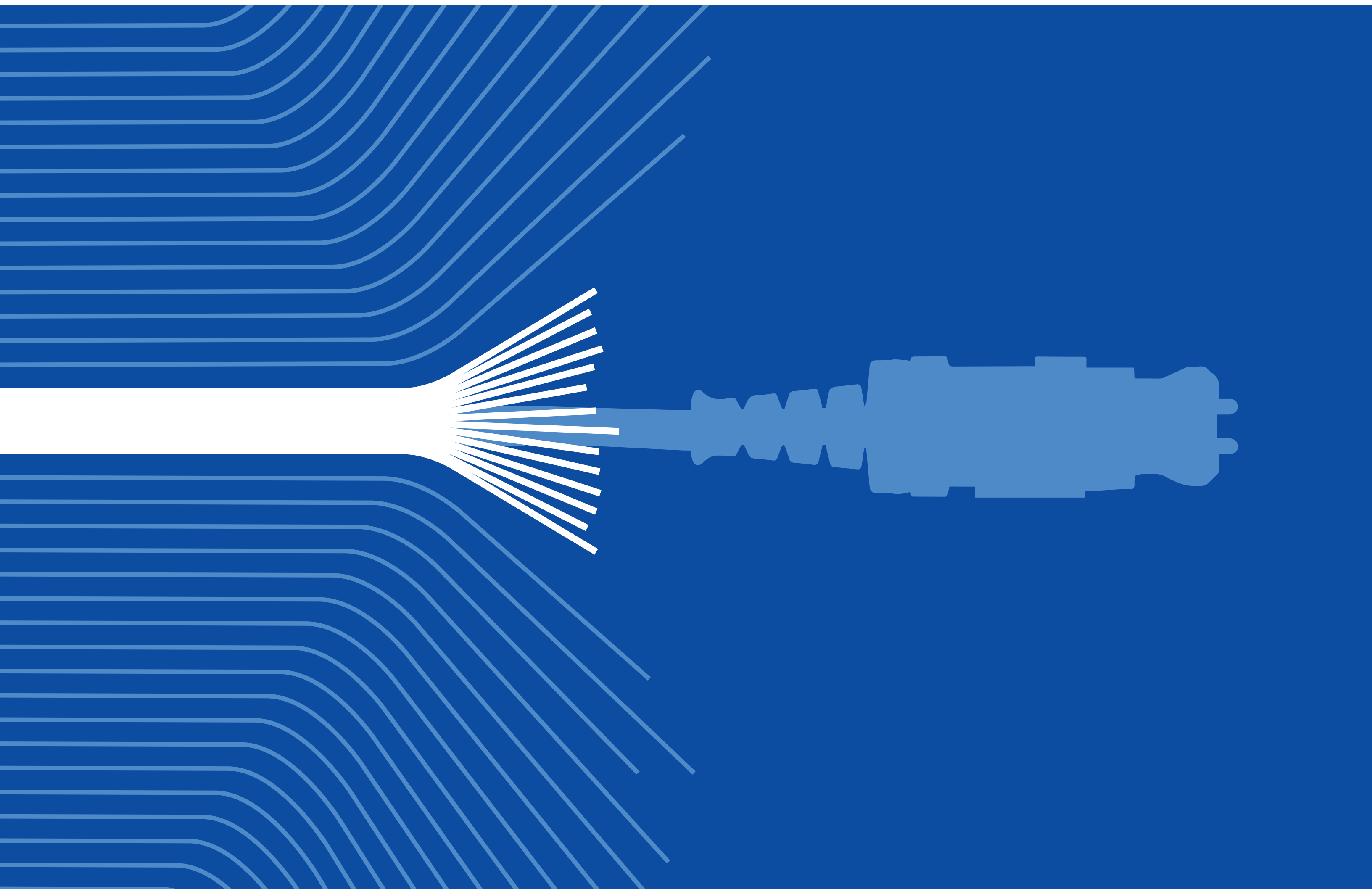

1.0 Introduction

Crimp strength is essential to the integrity and reliability of a patch cord or any connectorized fiber optic cable. A poor crimp will lead to mechanical distress resulting in optical performance degradation or even a complete failure of the cable assembly.

A good crimp does not solely depend on the crimp components quality, but also on the variations in the cable jacket diameter, amount of aramid yarn and jacket thickness as well as the operator's training and manufacturing engineering support. The purpose of this document is to provide guidance on SENKO's recommended procedures for fiber optic connectors crimping methodology.

2.0 Overview

Crimping was invented for electrical contact as an alternative to soldering. For an electrical contact to provide the best possible performance, it is vitally important that it is terminated correctly. The ideal crimp joint combines low electrical resistance with good mechanical strength. To achieve this, the wire of the cable is compressed within the crimp terminal to provide the best electrical conductivity. Crimp not only will provide the greatest surface area for electrical contact, but it also prevents oxygen or moisture from reaching the metal of the wire and terminal, reducing the possibility of corrosion.

Fiber optic connectors crimping follow much the same principles as crimping the electrical contacts with the goal to provide mechanical strength and additional levels of fiber protection. After crimping fiber optic connectors correctly, the cable assembly has the strength to withstand a required amount of pulling force that could occur during installation and service. Proper crimping ensures that force is transferred to the connector itself and not to the glass fiber.

The crimping process involves the connector body, a metal crimping sleeve (or a ring), and the cable strength members called aramid yarns (also known by the trade name Kevlar®). It is important to note that cable manufacturers use different aramid yarn Denier (D) which is the unit measuring the weight and thickness of the individual threads. Cable with a higher Denier will be stronger and more durable than the same cable with a lower Denier. The cable strength only as good as the strength of aramid. In addition to the quality of the aramid there are many others nuances that ensure the reliable crimp.

There are two areas in the connector where crimping applies: the back-post with the crimp ring and the aramid yarn in between and the cable jacket as an additional option. Back-post crimping provides strength preventing cable damage or fiber breaking under heavy tensile loads. Securing the cable jacket with a crimp helps prevent the jacket from detaching or twisting. Due to its combination of being a lightweight material with high tensile modulus, high tensile strength and wide working temperature range, aramid yarn is used as the main strain relief for fiber optic cables. Crimping of the aramid is critical to maintaining structural integrity, hence improving long term reliability. Failure of proper securing the aramid crimp will transfer tensile loads onto the fiber glass that strain relief boots are unable to compensate for. Under such conditions there is an immediate adverse impact on both short- and long-term cable integrity as well as the optical performance.

The cable jacket provides additional protection for the relatively more fragile buffered fibers from mechanical and environmental conditions. One must bear in mind that due to inconsistencies of cable jacket outer diameter, shrink rates, thickness and hardness of material type; jacket crimping cannot be as consistent as that of aramid crimping. With jacket wall thickness and diameter variations crimping the jacket could interfere with of fiber movement inside the connector. When the spring-loaded ferrule during connection is compressed and retracted back it is imperative for the fibers keep moving freely as the fiber jamming inside would adversely impact optical performance and reliability.

Crimping involves selecting a proper crimp tool – for each connector type, the connector manufacturer specifies the tool, die set (hexagonal or round cavity), crimp sleeve, crimp force and post crimp connector ring dimension range. Below is a sample of manufacturing instructions that verifies calculated post crimp tube dimensions.

Often the question arises on how to calibrate the crimp tool. Calibration is not as straight forward as simply using a traceable artifact. As cable constructions vary from vendor to vendor it is advisable to verify proper crimp tool performance by measuring required tensile forces following GR-326 standard or end user requirements. SENKO suggests manufacturing engineering or quality departments to measure crimp dimensions on actual products periodically to ensure that the crimp is in range and in-line with the original qualification data.

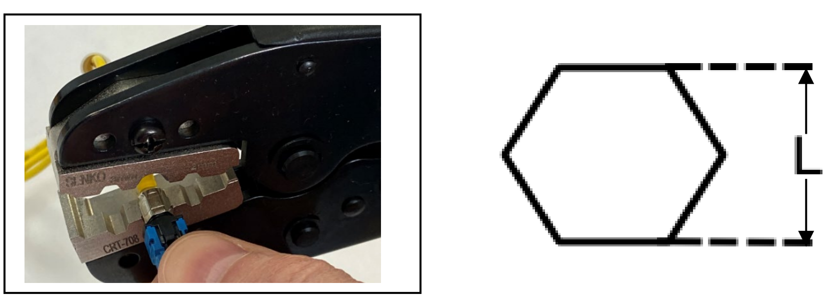

Figure 1: Example of crimp check in manufacturing

The part of the back post of a connector is usually not smooth – it is textured or knurled, because this increases the contact surface area. The part of the back post of a connector is usually not smooth – it is textured or knurled, because this increases the contact surface area with the crimp ring.

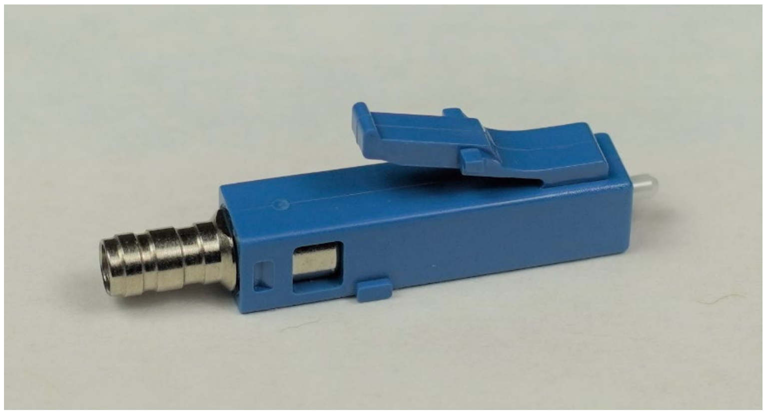

Figure 2: Sample of Senko LC with textured back post

It is equally important prior crimping to evenly distribute the aramid yarn around without bunching it on one side. To do this a brush similar to the one pictured below is recommended. This will help to maximize the final pull force of the connector.

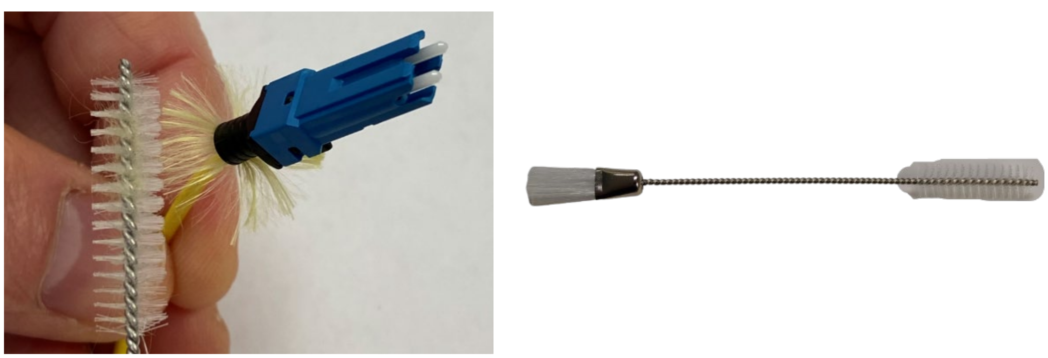

Figure 3: Example of spreading aramid yarn around back-post

Using the wrong crimp tool or die set can result in a damaged connector or jamming the fiber. If the crimp is too tight it could result in cracking of the metal ring. Contrary, if the crimp is too loose it could allow aramid slippage, decreasing the pull force. Therefore, it is important to use the connector manufacturer's recommended manual crimp tool or an automated crimp tool. Automated crimp tool typically is pneumatic, which allows the handling of the connector with both hands ensuring the proper position of the aramid and the crimp ring. It also offers better repeatability and yields by improving process control while decreasing operator fatigue.

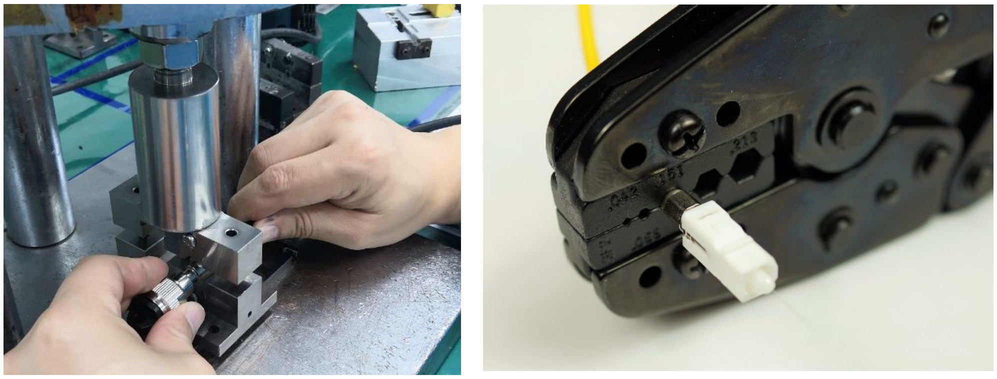

Figure 4: Automated (left) vs. Manual (right) crimping

The quality of a crimp ring also plays an important role. Different metal alloys, material coatings and wall thicknesses are important factors. Some metals are more brittle that others, ideal alloys are cost-effective and semi rigid, they cannot be brittle and cannot rust or discolor.

Figure 5: Example of thin wall (poor quality) left vs. thick wall (good quality) right

3.0 Jacket Crimping Improvement Solutions

The use of a two-step crimp ring is the conventional method of crimping both the back-post and the cable jacket. This works well for cables of 3mm outer diameter or greater. However, when the diameter is less than 3mm, issues could arise from differences in jacket thickness and other cable construction variations.

No single crimp ring can accommodate these variations, and having multiple sizes crimp rings for each cable type is neither practical nor economical. SENKO suggests four methods to improve cable jacket crimping:

1. Application of epoxy
2. Usage of heat shrink tube
3. Usage of pin tube
4. Use of Crimp Sleeve with Integrated Heat Shrink Tubing

3.1 Application of Epoxy

When the cable jacket is less than nominal, jacket crimp may be insufficient. In such cases silicone-based epoxy can be applied to the end of the crimp ring after crimping. The epoxy adds low strength adhesion of the crimp ring to the cable jacket, thereby increasing tensile load resistance, and thus improving jacket pull and twist performance. The application of the epoxy is a good solution; however, it’s the least effective of the three recommended by SENKO. Using this methodology prevents over crimping which allows the fibers to continue moving freely.

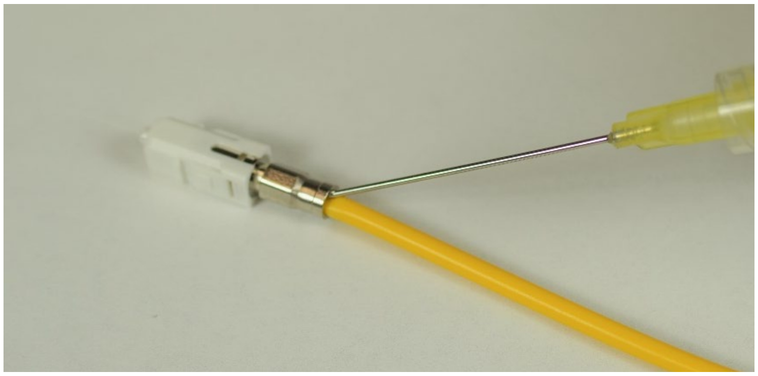

Figure 6: SC Example

3.2 Use of Heat Shrink Tubes

The use of heat shrink tube is a quick, easy and effective method to increase the cable outer diameter and thickness. The additional thickness of a heat shrink tube allows the crimp ring to bite into it, increasing jacket pull and twist performance. Risk of over-crimping is very low due to the softness of the heat shrink tube and increased cable diameter. Heat shrink tubing also helps in the event of cable jacket excessive shrinkage during temperatures fluctuations. Heat Shrink will provide continuity as it has no shrinkage after installation.

3.3 Use of Pin Tube Insert

The use of a pin tube has the effect of not only increasing the cable jacket outer diameter, but in cases where the jacket is soft, it prevents the jacket from collapsing. This allows the crimp ring to firmly bite into the jacket and in turn it allows for a higher than normal crimping force to be applied whilst protecting the fibers from over-crimping. The extra crimping force transferred to the pin tubes allows for further reducing of the crimp rings' inner diameter when fully crimped. This gives the crimp ring a grip on to the cable jacket, increasing jacket pull and twist performance. This method provides the strongest retention often exceeding GR requirements. Use of pin tubes with single fiber connectors is simple. After the cable is prepared and the fiber stripped in accordance with the corresponding termination procedure, the pin tube is installed between the buffered fiber and aramid strengthening members. See example below./m,

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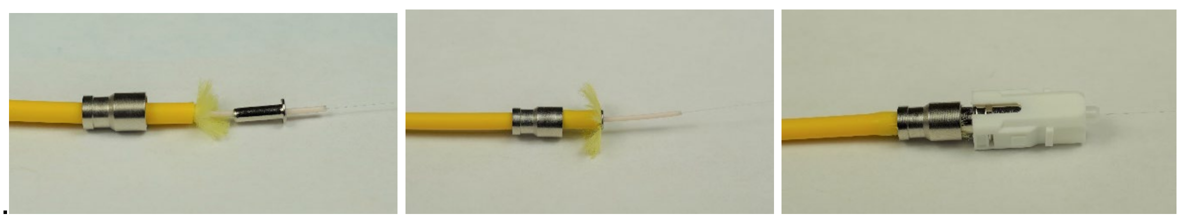

Figure 7: Example of using a Pin Tube Insert

Of course, use of a pin tube is not always possible as in the case of armored and other types of reinforced cables. In these cases, heat shrink tubing would be recommended to effectively increase jacket thickness and cable outer diameter to improve crimp performance.

3.4 Use of Crimp Sleeve with Integrated Heat Shrink Tubing

For cable diameters with 2.00mm and less, the use of crimp sleeve with integrated heat shrink tubing can be utilized. This is effective for the cables with thin jackets, because it prohibits direct jacket crimping which would crush the fiber and results with more than enough jacket pull and twist performance. Note that this is the standard solution for SENKO LC connectors.

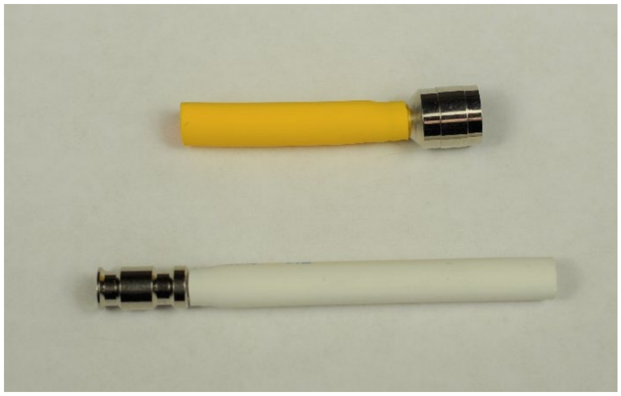

Figure 8: Example of Crimp Sleeves with Heat Shrink Tubing Integration

4.0 Conclusion

Crimping is an important part of the termination process which will improve longevity and handling of cable assemblies. Improper crimping could lead to catastrophic failure and costly delays. Even for a seemingly straightforward step such as crimping, you need to have good manufacturing support, procedures, the right tools, good-quality components, and well-trained operators. We encourage you to contact SENKO representative if you have any additional questions.

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