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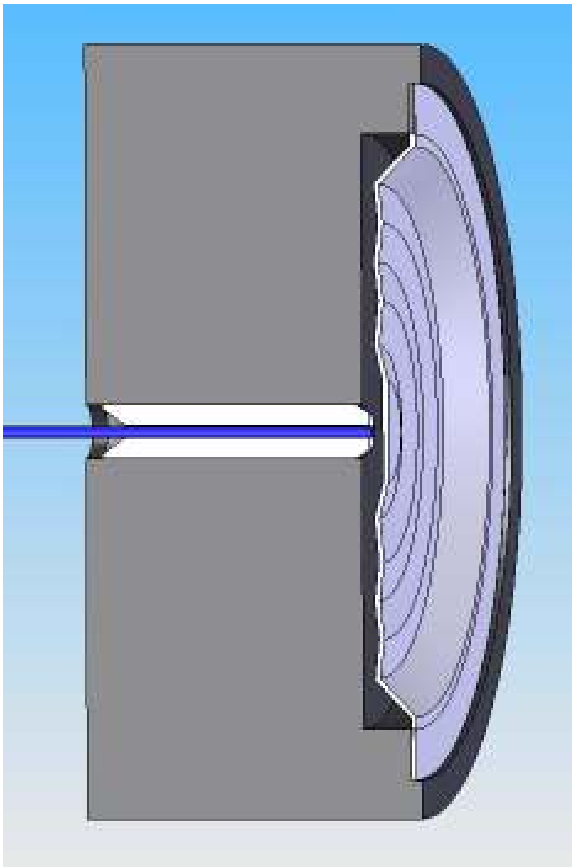
DavidsonSensors™

Fiber Optic Connector Termination Standard



Davidson Fiber Optic Sensing System

- DavidsonSensors™ Measure Temperature, Pressure, and Force
- DavidsonSensors™ Transmit Intrinsically Safe Signals to Passive Fiber Optic Transducers
- DavidsonSensors™ are Immune to Lightning Damage and Grounding Problems
- DavidsonSensors™ are Immune to Electromagnetic and Radio Frequency Interference (EMI/RFI)
- DavidsonSensors™ Operate at 1000°F
- DavidsonSensors™ are Easy to Install and Require Very Low Maintenance

Fiber Optic Connector Connector Termination Standard

1. Introduction

Fiber optic sensing technology offers a number of advantages for measurement in harsh industrial environments. Fiber optic transducers are tolerant to high temperatures, intrinsically safe, and immune to electromagnetic interference.

Since many fiber optic transducers can be multiplexed with a multichannel signal conditioner, significant cost savings can be achieved. To realize the full potential of this technology, it is helpful for the user to understand some of the details about resolution and accuracy of the fiber optic sensing measurements.

This guide is intended to provide clear definitions of resolution and accuracy and to describe some of the factors that can affect accuracy under field conditions.

For more advanced information to help with the planning of a fiber optic sensing system, see the Davidson website at www.davidson-instruments.com.

2. Safety

The proper termination of an optical fiber involves several steps including removing the jacket, stripping the buffer, cleaning the fiber, cleaving the fiber, assembling the hardware, completing the termination, and disposing of the glass slivers. Please observe the following safety precautions when terminating fibers:

2.1 Training - Only properly trained technicians should handle bare fiber. Slivers of fiber can be very irritating if the slivers are allowed to penetrate the skin.

2.2 Safety Glasses – Safety glasses must be worn when handling bare fibers. Small slivers of glass could cause severe damage to the eye.

2.3 Isopropyl alcohol – Isopropyl alcohol is flammable and can irritate the eyes and skin.

2.4 Epoxy and other adhesives are flammable and can irritate the eyes and skin.

2.5 Bare fibers must be disposed of in containers designed for disposal. Small slivers of fiber can be collected using tape.

3. Fusion Splicing – The Preferred Method

Ideally, all terminations are made as permanent fusion splices using specialized equipment made for that purpose. Fusion splicing is accomplished by aligning the ends of two fibers and then melting the fibers with an electrical arc while forcing two glass fibers together. Figure 1 provides an illustration of a fusion splice.

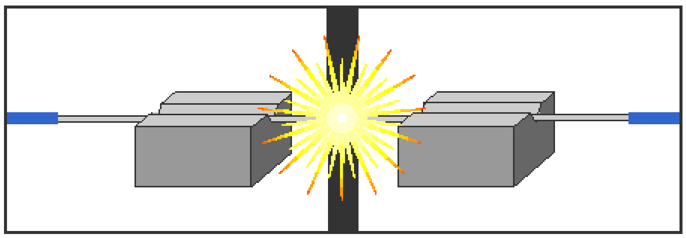


Figure 1 – Illustration of Fusion Splice

The result of a good fusion splice is a transparent and non-reflective joint that has essentially no losses. Fusion splicing has two downsides however:

- Fusion splicing requires specialized equipment and trained operators.
- Fusion splicing may require a hot work permit because of the high energy involved in the melting of the glass fibers.

In an emergency situation, a temporary mechanical connection may be made until a proper permanent fusion splice can be made.

3.1 Preparation for a Fusion Splice – For field terminations, the fiber optic cable should be secured to a junction box that will house the completed termination. The jacket and strength members in the cable should be removed and the individual color-coded fibers should be exposed.

The fusion splice kit will consist of a fusion splice protector to protect the bare fibers and to provide strength to the fusion splice joint. The splice protector should be positioned on the fiber before the fiber is stripped.

A fiber stripper should be used remove the buffer coating from the ends of the fibers to be spliced. The stripped fiber ends should be wiped clean with isopropyl alcohol and inserted into the fusion splicer.

3.2 Making and Inspecting the Fusion Splice – Automated fusion splicers inspect, align, and fuse the two fibers together and test the quality of the splice.

The splice should be rejected if the loss exceeds 0.1 dB or there is any indication of a bubble at the joint.

3.3 Protecting the Fusion Splice – Automated fusion splicers have heaters that are used to melt a heat shrink tube around the stripped fiber. Once the fusion splice protector is in place, the fusion splice is complete.

3.4 Fiber Management – The optical fibers should be coiled with a generous bend (no sharp corners) and secured in an orderly manner inside the enclosure or fiber management box that may be located inside of a junction box. Take care to avoid pinching or crimping any fiber. Allow adequate slack in the fiber so that no fiber is strained anywhere along its length. Finally, label the connections to simplify diagnostics and testing of the optical circuit.

4. Mechanical Splice – Emergency Repair

In an emergency situation, a temporary mechanical connection may be made using a mechanical splice until a proper permanent fusion splice can be made. A mechanical splice is an optical junction where the fibers are precisely aligned and held in place by a self-contained assembly. By aligning the fibers along a common axis, the light can pass from one fiber to another.

4.1 Preparation for a Mechanical Splice – For temporary field terminations, the fiber optic cable should be secured to a junction box that will house the completed termination. The jacket and strengthening fibers should be removed and the individual color-coded fibers should be exposed. It may be necessary to make two connections if slack cable is not available.

The mechanical splice kit will consist of a one- piece crimp sleeve filled with an index matching gel that also acts as the mechanical splice protector. The buffer coating from the mating fibers should be removed using a fiber stripper. The mating fibers should be cleaved, wiped clean with isopropyl alcohol, and inserted into the mechanical splice holder.

4.2 Making the Mechanical Splice – The splice is made when the fibers have been pushed together and the fibers are crimped into position where they exit the mechanical splice protector.

4.3 Fiber Management – The optical fibers should be coiled with a generous bend (no sharp corners) and secured in an orderly manner inside the enclosure or fiber management box that may be located inside of a junction box. Take care to avoid pinching or crimping any fiber. Allow adequate slack in the fiber so that no fiber is strained anywhere along its length. Finally, label the connections to simplify diagnostics and testing of the optical circuit.

5. Mechanical Connectors – Appropriate for Temporary Connections

Davidson recommends that mechanical connectors be limited to use in those situations where periodic connect and disconnect is required. Mechanical connections are not a good substitute for permanent fusion splices especially in field conditions. Davidson uses the most rugged and dependable connectors available but even these connectors are not as good as a permanent fusion splice connection.

The standards of acceptable quality of the connectors and terminations for fiber optic sensing systems exceed the standards for digital signal quality required in telecommunication systems. When making a mechanical connection, it is important that the termination be made and inspected in compliance with Davidson termination standards. Severe degradation will result from poor terminations.

5.1 Selecting the Connector – Most fiber optic connectors are designed for use in controlled environments and are not appropriate for use in harsh industrial environments. For outdoor field terminations, especially in harsh industrial environments, Davidson recommends the use of its line of ruggedized connectors or commercial FC/APC connectors.

The commercial FC/APC connector is one of the most commonly used fiber optic connectors. It has a bayonet for alignment and a rugged 2.5mm zirconia ferrule. Davidson ruggedized connectors provide further mechanical protection offers a reliable connection available for field applications.

The fiber is secured to the ferrules using Epo-Tek 353ND epoxy. The stripped and cleaned optical fiber is wetted with the epoxy and inserted into the zirconia ferrule. The epoxy may be cured with a heat gun or in an oven and then allowed to cool.

5.2 Preparing the Fiber – For field terminations, the fiber optic cable should be secured to a junction box that will house the completed termination. The jacket and strength members should be removed and the individual color-coded fibers should be exposed.

The fiber connector kit will consist of strain relief boots and buffer tubes to provide handling protection and strength when mounted onto connectors. The strain relief components should be positioned on the fiber before the fiber is stripped.

The buffer coating should be removed from the fiber using a fiber stripper. The fiber should be wiped clean with isopropyl alcohol and inserted into the zirconia ferrule with about 1 mm of fiber sticking out beyond the end of the ferrule.

After cooling, the fiber is scribed and cleaved nearly flush with the end of the ferrule. The ferrule is now ready for polishing.

5.3 **Polishing to Perfection** – The most critical step in the installation and commissioning of a fiber optic sensing system is the polishing of the end face of the connector ferrules. Connectors are the weakest link in most systems. In fiber optic sensing systems, proper polishing is the key to success. The consequences of a poorly polished connector ferrule could be enormous and so great care should be taken with the polish.

If the length of a cable run can be determined during the planning stages, it makes good business sense to purchase the cables with factory polished connectors on each end. When the distance is uncertain, it makes sense to order the cables with factory polished connectors on one end to leave only one end to be terminated manually in the field.

Polishing finalizes the end face of the connector and cleans the surface. The quality of the polish has a direct impact on such optical performance parameters as insertion loss and return loss. Reliable polishing processes rely on proper training and a well-equipped termination tool kit.

Special grit papers, holding fixtures, polishing pads, and procedures are required for a good polish. It is crucial that the fiber and ferrule not only be formed perfectly to align with a mating connector, but that the polished end be free of any dirt. Failing to do so can cause high loss or high reflection,and can contaminate the adapters to which the connectors and patch cords will be connected.

5.4 **Inspection and Acceptance Criteria** – After polishing, the end of the ferrule must be cleaned and examined to determine if the connector meets the acceptance standard. The following table defines the acceptance criteria:

Visual at 400X	Acceptance Criteria
Surface Quality	Smooth even polish without scratches
Cracks	No cracks across the core
Chips	No chips around the edges
Dirt	No evidence of any contaminant

5.5 **Managing the Fibers and Mating the Connectors** – The optical fibers should be coiled with a generous bend (no sharp corners) and secured in an orderly manner inside an enclosure or fiber management box or junction box. Take care to avoid pinching or crimping any fiber. Allow adequate slack in the fiber so that no fiber is strained at the bulkhead where the connectors are mated.

> **Before mating two connectors at the bulkhead, both connectors must be cleaned with isopropyl alcohol and special fiber optic connector cleaning cloths**.

The connectors are spring loaded and fit into a precision sleeve. In high temperature environments use adapters with zirconia alignment sleeves. Take care when inserting the connectors to assure that excessive force is not required to complete the connection. If the zirconia alignment sleeve is broken, the optical fibers will not be aligned. Finally, label the connections to simplify diagnostics and testing of the optical circuit.

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