Fiber Termination
Where we’ve been and where we’re going

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History of light in communication

- A long history ...
  - The ancients
  - First long distance use
  - First long distance voice transmission

- Escape from the line of sight requirement
  - The attenuation barrier!
The first demonstration of total internal reflection was performed by British physicist John Tyndall around 1870 in a stream of water.
In 1880, William Wheeler, a Massachusetts engineer, patented a system for lighting rooms in buildings using pipes with reflective inner surfaces.

Thomas Edison’s electric light bulbs came along a few years later and relegated Wheeler’s idea to the dust bin of history.
“Light pipes”

- One of William Wheeler’s original patent application drawings.
The functions of a connector

- The connector holds the fiber so that the end can be polished, and then lined up with another fiber very precisely so that light can pass from one core into the other.
The functions of a connector

A spring action is often used to force the fibers one towards the other.
The functions of a connector

- The two primary differences among connectors are:
  - 1. the termination method
  - 2. the mating type
Termination methods

• Five primary termination methods:
  1. Mechanical/polish
  2. Adhesive/polish
  3. No-epoxy/no-polish
  4. Pigtail and splice
  5. Factory preterminated cables
Mechanical/polish termination

The fiber is inserted all the way through the connector. The fiber and the cable are crimped or clamped into the connector. The excess fiber is then scored and removed. The small nub of fiber is then polished away, leaving a smooth fiber end to transmit and receive light.
Adhesive/polish termination

Cable secured in connector by adhesive or mechanical method.

Adhesive holds the fiber firmly in the connector ferrule.

Excess fiber is scored and removed.

The remaining fiber and adhesive is then polished down to the end-face of the ferrule.

The adhesive is injected into the ferrule (in the field or pre-injected by the manufacturer).

The fiber is then inserted all the way through the connector.

When the adhesive has cured, excess fiber is then scored and removed.

The small nub of fiber and adhesive is then polished away, leaving a smooth fiber end to transmit and receive light.
A variety of adhesive types are available:

1. Epoxy
2. Anaerobic
3. Ultra-violet cured
4. Pre-injected

Adhesive holds the fiber firmly in the connector ferrule.

Fiber end polished to same radius curve as ferrule end-face.
Adhesive/polish connector termination

- Apply adhesive to the connector
- Insert bare fiber into connector
Prepare to polish fiber end face

Score the bare fiber

Remove fiber stub
Polish fiber end face

Air polish

End face polish
Inspect the ferrule

- Good
- Epoxy
- Cracked Fiber
- Bad Cleave
No-epoxy/no-polish termination

- In the field a technician cleaves the fiber, inserts it into the connector and mechanical splice inside, and clamps it in place.

Buffered fiber or cable jacket secured in connector by mechanical method.

Drop of index-matching gel provides optical interface for cleaved fibers.

Mechanical splice joins factory-installed fiber stub and fiber being terminated.

Adhesive holds the factory-installed fiber stub firmly in the connector ferrule.

Fiber end polished and tested at the factory to same radius curve as ferrule end-face.
No-epoxy/no-polish termination

Buffered fiber secured in connector by mechanical method.

Drop of index-matching gel provides optical interface for cleaved fibers.

Mechanical splice joins factory-installed fiber stub and fiber being terminated.

A variety of no-epoxy/no-polish types are available:
1. Mechanical splice with no visual verification
2. Mechanical splice with visual verification
3. Reusable mechanical splice with visual verification
4. Fusion splice on connector
No-epoxy/no-polish connector
with no visual verification

Prep, mark fiber and strip buffer per instructions

Cleave fiber
### Premium cleaver vs. standard

Many installers are discovering the benefits of a high performance premium cleaver.

<table>
<thead>
<tr>
<th>Standard cleaver</th>
<th>Premium cleaver</th>
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<tbody>
<tr>
<td>Technician should check each cleave with a microscope</td>
<td>Higher productivity—reliable cleaves do not need to be checked</td>
</tr>
<tr>
<td>If termination is unsuccessful, tech must disassemble and re-cleave</td>
<td>Higher productivity—no time wasted terminating with a bad cleave</td>
</tr>
<tr>
<td>Fiber shards must be manually secured and stored</td>
<td>Safer—automatically stores fiber shards for later disposal</td>
</tr>
<tr>
<td>Lasts a few thousand cleaves</td>
<td>Lasts for many thousands of cleaves</td>
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<tr>
<td>Cleaves are more variable and can result in higher loss (though still standards compliant)</td>
<td>Better installed performance—better cleaves result in lower loss, especially with singlemode fiber</td>
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<tr>
<td>Lower initial investment</td>
<td>Higher initial investment</td>
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No epoxy/no polish connector

Always inspect the cleave when using standard cleave tool.
No epoxy/no polish connector with no visual verification

Insert cleaved fiber and activate splice

Crimp connector collar

• ‘Blind’ process does not provide opportunity to verify quality of mechanical splice
No-epoxy/no-polish connector with visual verification
No-epoxy/no-polish reusable connector

1. Snap the VFL into the holding tool
2. Snap the adapter into the tool
3. Insert the fiber jumper into the VFL and the adapter
4. The assembled tool
5. Laser light from the VFL emits from the adapter
No-epoxy/no-polish reusable connector
No-epoxy/no-polish reusable connector

- Cleave fiber with either standard or premium cleave tool.
No-epoxy/no-polish reusable connector
No-epoxy/no-polish reusable connector

Slide the clamp toward the rear of the connector to secure fiber

A stylus is available in the base of the holding tool

Clamp in closed position

Absence of light in window means the termination is successful

If light is still present after closing clamp, re-open, move the fiber slightly and try again; connector can be reused up to five times.
No-epoxy/no-polish reusable connector
No-epoxy/no-polish reusable connector

- If terminated optical fiber node fails link test, connector can be removed and reterminated in the field.
Fusion splice-on connector
Fusion splice-on connector

Thread buffered fiber through components

Load fiber into holder
Fusion splice-on connector

Prep and cleave fiber
Perform fusion splice
Fusion splice-on connector

Slide protection sleeve and place in heater

Perform fusion splice
Fusion splice-on connector

Complete connector assembly process

Remove holding string & snap on housing
A factory-installed and tested connector with a pigtail of tight-buffered fiber is brought to the job-site. A technician merely cleaves the fiber being terminated, inserts it into the splice, and clamps it in place (or, alternatively, fuses the two fibers with a fusion splicer).
Splices

Two types of splices commonly in use

1. Mechanical
Splices

2. Fusion
An alternative to termination ...

• The ultimate choice of which field termination method to choose …

  is none at all!

• Pre-terminated backbone or horizontal cable runs cut training and installation time even more dramatically than no-polish solutions.
Preterminated cables for current and future apps

Preterminated cables

MTP/MPO Migration

100BASE-SR10 Proposal
Three variants, all looking into the MDI receptacle with the keyway on top

- Side-by-Side Ports
  - Transmitter: T x T x T x T x T x T x T
  - Receiver: R x R x R x R x R x R x R

- Vertically Stacked Ports
  - Transmitter: T x T x T x T x T x T x T
  - Receiver: R x R x R x R x R x R x R
  - Specify:
    - relative position of Rx and Tx
      - Side-by-Side Ports follow IB
      - Vertical and Single analogous
    - 12-position rows with outer positions unused to mitigate alignment challenges

- Single Port
  - Transmitter: T x T x T x T x T x T x T
  - Specify the MPO connector:
    - Pinned (male) in MDI receptacle
    - Unpinned (female) on patch cord

Bicsi
An alternative to termination ...

Pre-terminated cable assemblies and modules can slash installation time and cost, but depend on careful design and measurement.

• The technician on the job merely unreels the cable and plugs it in!
Preterminated cables
Measure twice, order once
High performance LANs allow for lower loss in cabling budget than older networks.

- Proper cable handling, termination and cleanliness practices are more critical.
  - TIA still recognizes .75dB loss per mated connection.
Typical End Face Geometry
Hand Polish

- Important to maintain acceptable end face geometry during hand polishing
- Poorly controlled end face geometry leads to high Insertion loss
Typical End Face Geometry

Factory Polish

- Machine polishing in a controlled environment enables higher degree of repeatability through SPC techniques.
Application comparison

- Factors in selecting a termination method:
  1. Adhesive/polish
  2. Mechanical/polish
  3. No-epoxy/no-polish
  4. Pigtail and splice
  5. Preterminated cables

- Decreasing training and field termination labor time
- Increasing cost of materials
- Decreasing cost of materials
- Increasing training and field termination labor time