A "One & Done" approach for Precision Fiber Splicing

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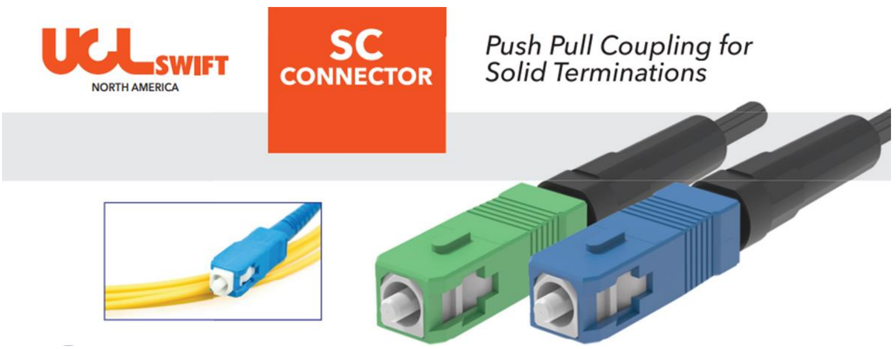
Agenda

1. UCL Swift Corporate Profile
2. Industry Trends re: Fiber Splicing
3. Key Topics to consider with Fiber Splicing
4. Case Study: Lessons Learned from the Field
5. Activities with Service Providers
6. Fiber Splicing “Best Practices”
7. Summary – 3x Important Take Aways

Corporate Profile

"All-In-One" Fusion Splicer Tools

Global Presence



Fusion Splice-On Connectors (FSOCs)

Production Capacity: >40M fiber terminations per year

TAA-compliant Manufacturer

Industry Trends re: Fiber Splicing

Issues with Legacy Methods for Field Connectorization

Mechanical Connectors

- **Labour-intensive, detailed Installation Process (>20+ steps!)**
- High Count Tool Kit – 18+ items!
- Premium-priced Connectors
- Higher dB Insertion Loss (typical) per Connector vs other methods
- **Higher connector waste factor (Estimated 15%-20%)**
- **Requires index-matching gel to compensate for connection gaps!**
- Manually discarded Fiber Shards
- Field Crimping Tool non-intuitive
  No Auto-Reading / Splice Auditing
  No Instrument Error Detection

Traditional Pig-Tails

- Requires Stripping Tool, Cleave Tool, Cleaning Kit , Fusion Splicer
- Pre-Cleaved connectors exposed to damage, elements and potential contamination (dB loss)
- Pigtails ⬄ Splice Trays
- **Manual stripping can be inconsistent and problematic**
- Error detection at fusion step requires re-work in most cases
- Training and expertise ramp-up inconsistent & time-consuming

Pre-Terminated Cables

- **Too many SKU's and excessive inventory needed to accommodate all lengths**
- Larger pathway size for connectorized cable complicates the installation
- **Cable slack management becomes costly with added storage/pedestal footprint**
- Cables and connectors subject to damage due to incorrect pulling methodology

Key Topics to consider with Fiber Splicing

1. Mechanical Connectors (MSOCs) vs. Fusion Splice On Connectors (FSOCs)

2. Mechanical/Manual Stripping vs. Automatic Thermal Stripping (ATS)

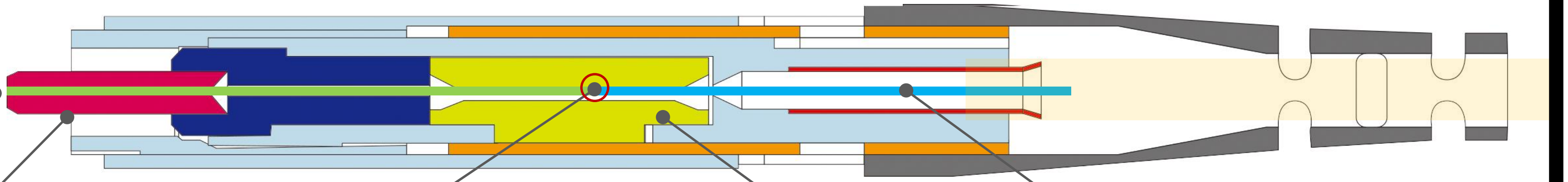
3. Mode Field Diameter (MFD) Issues

4. Active Clad-alignment vs. Core-alignment Fusion Splicers

5. Lessons Learned from the Field

Mechanical/Manual Splicing

Basic structure of the Mechanical Splice-On Connector (MSOC)



End face of APC/UPC field connector requires inspection/(re-)cleaning

Ferrule needs to be cleaned

Index-matching gel needed at splice gap

Filed V-groove/ Crimp Point

Field fiber needs to be manually stripped & cleaned

Fusion Splicing

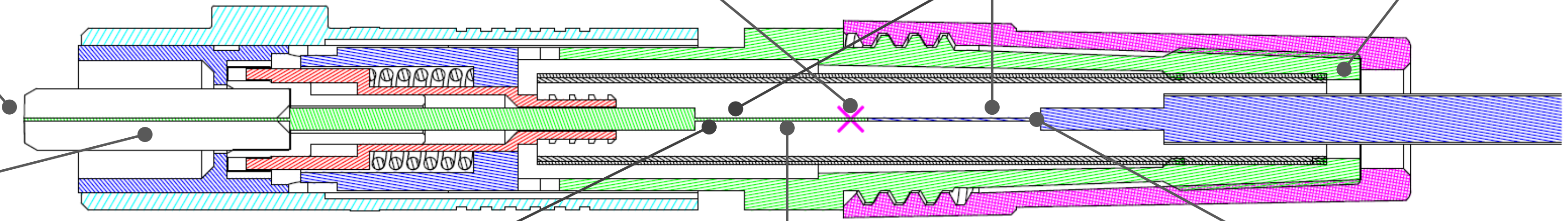
Basic structure of the Fusion Splice-On Connector (FSOC)

Pre-polished end face of connector from factory

Fusion splicing point

Fibers Cleaved

Cable clamping part



Capped ferrule sub-component: designed & manufactured for quality & consistency

FSOC pig-tail needs to be thermally stripped

Splice point protection with heat shrink strength member

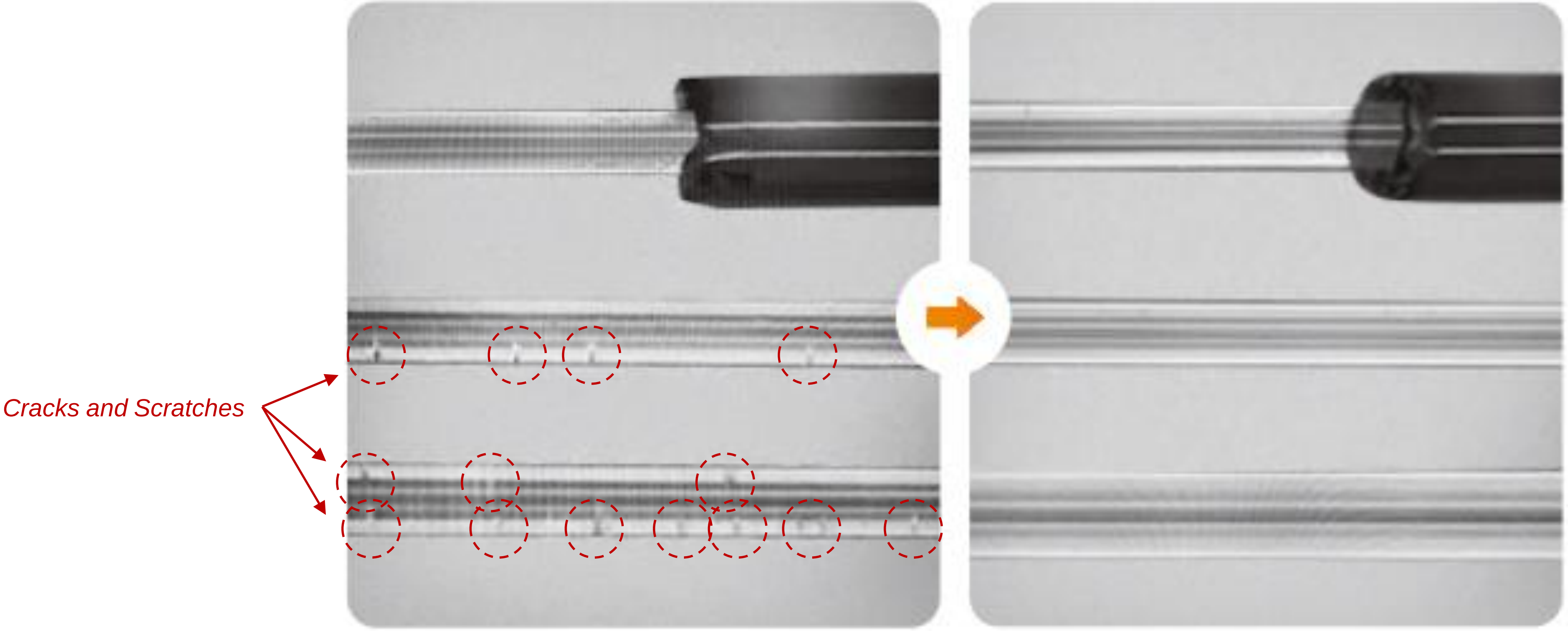
Field fiber needs to be thermally stripped & cleaned

Insertion Loss Range

Mechanical/Manual Splicing	0.25dB → 0.50dB
Fusion Splicing	0.12dB → 0.15dB

Improved Performance & Reliability with ATS

- Precision Fusion Splicer tools with Automatic Thermal Stripping (ATS) functions eliminate cracks and scratches caused by Mechanical/Manual Stripping methods.



Mechanical/Manual Stripping

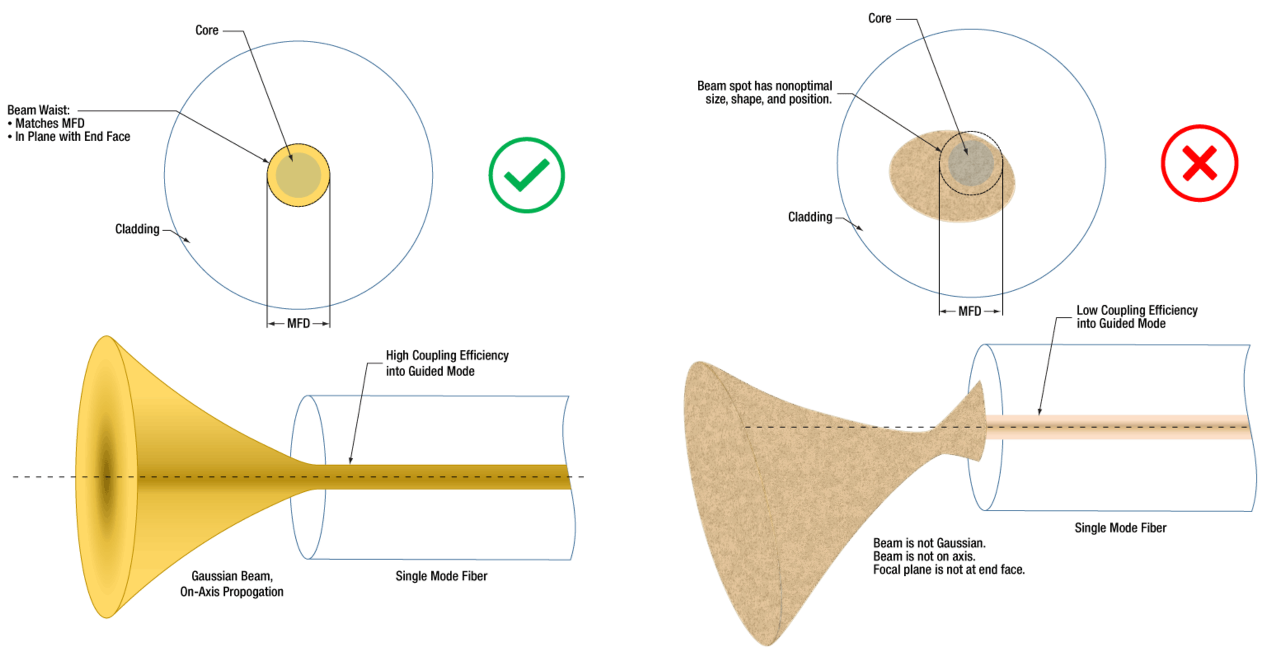
Automatic Thermal Stripping (ATS)

Mode Field Diameter (MFD)

Type	ITU-T Std	Common Name	Core Size	Min. Bend Radius	Typical MFD @ 1310nm	Typical MFD @ 1550nm
Single Mode Fiber	G.652.D	Standard SM Fiber	8.3 µm	30 mm	9.2 ± 0.4 µm	10.4 ± 0.5 µm
	G.657.A1	Bend Insensitive Fiber	8.3 µm	10 mm	8.6-9.2 ± 0.4 µm	9.65 ± 0.5 µm
	G.657.A2	Bend Insensitive Fiber	8.3 µm	7.5 mm	8.6-9.2 ± 0.4 µm	9.8 ± 0.5 µm
	G.657.B2	Bend Insensitive Fiber	8.3 µm	7.5 mm	7.5 ± 0.4 µm	9.8 ± 0.5 µm
	G.657.B3	Bend Insensitive Fiber	8.3 µm	5 mm	8.6-9.2 ± 0.4 µm	9.8 ± 0.5 µm

- **MFD mismatches introduce Insertion Losses**
- **Understand uni-directional impacts (e.g. OTDR):**
  - $MFD_{large} \Leftrightarrow MFD_{small}$ = Erroneous "Gainer"
  - $MFD_{small} \Leftrightarrow MFD_{large}$ = Exaggerated "Loser"

Engineering/Planning
Loss Range for mismatched MFD:
.01dB to .04dB



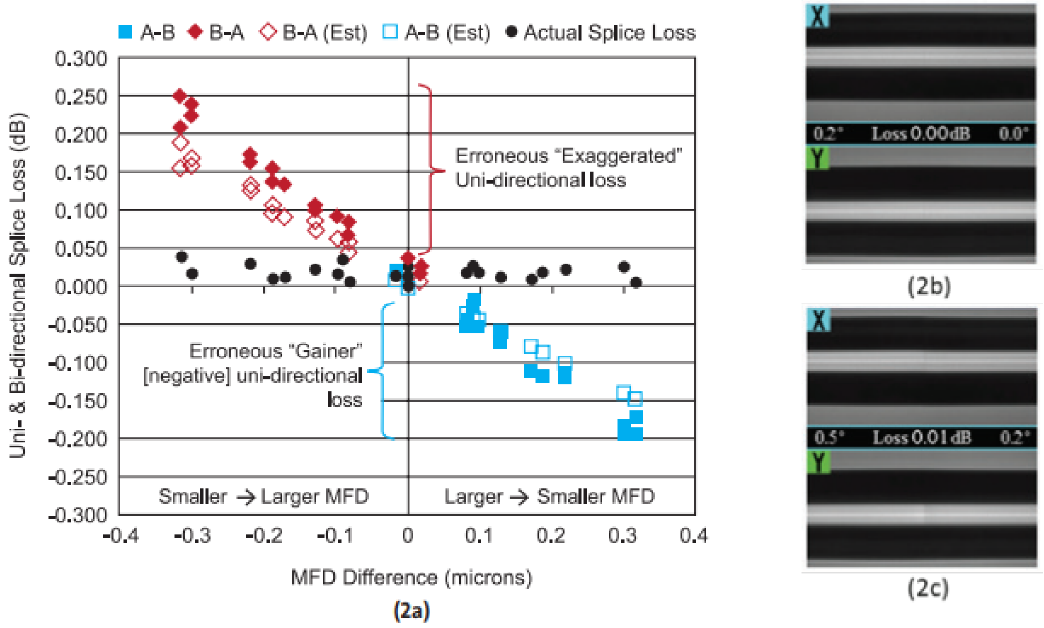
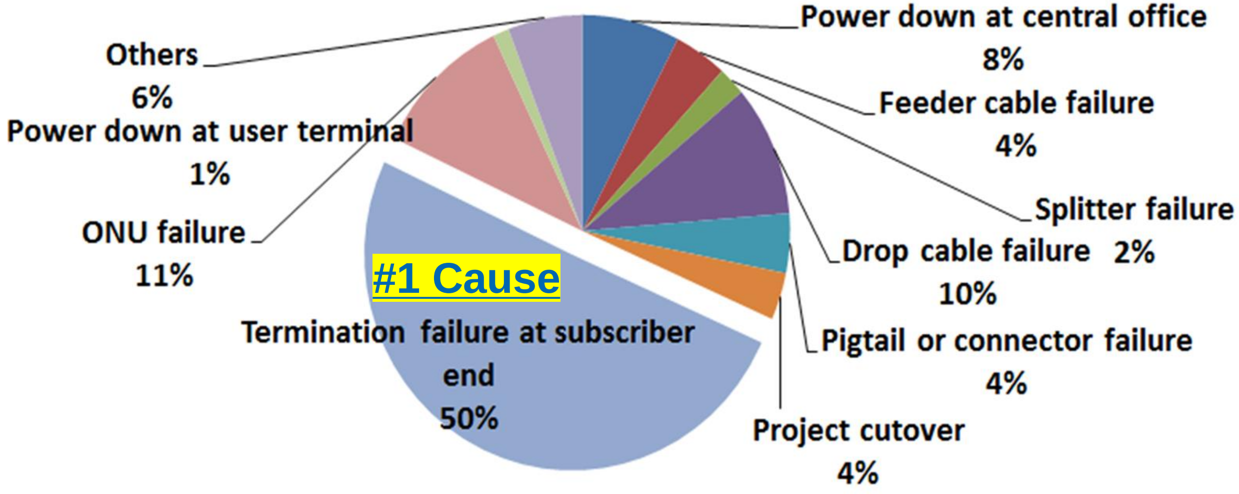


Figure 2a. Comparison of uni-directional and bi-directional OTDR inspection results of spliced SMF-28e+® G.652.D fiber samples with known MFD mismatch. **2b** and **2c** are representative fusion splicer machine images of spliced SMF-28e+ fiber with MFD mismatches.

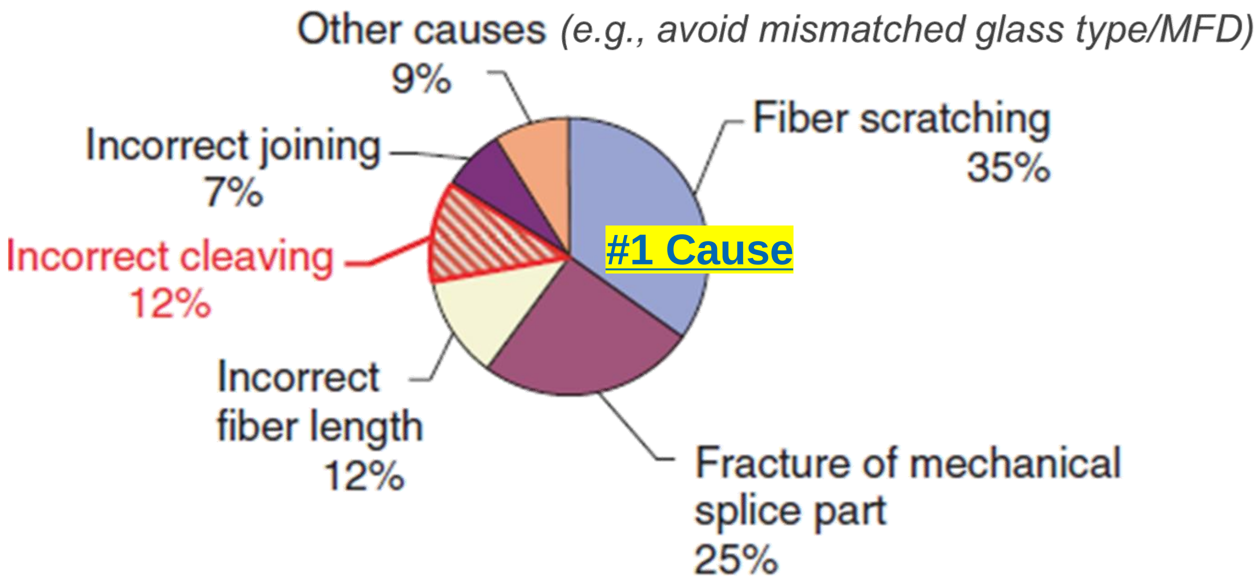
Source: *Corning*

Case Study: Lessons Learned from the Field

Statistical Distribution of FTTH Failures



FTTH Termination Failures At Subscriber End Categorized By Type of Identified Failure



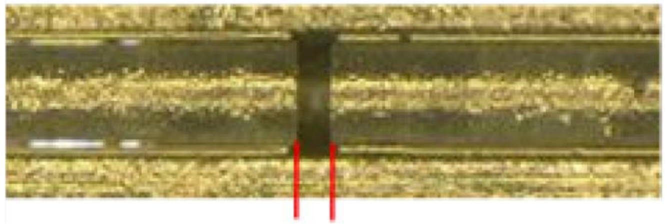
Source: World Class FTTx Provider

Key Observations:

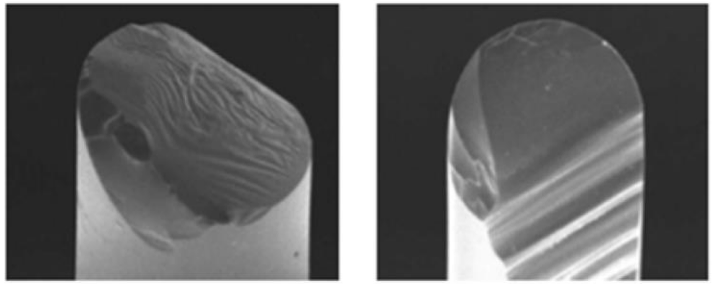
1. **50%** of FTTH Failures overall attributed to Termination Failure at Subscriber End
2. **35%** of FTTH Termination Failures at Subscriber attributed to Fiber Scratching (i.e., improper stripping)

Main Causes of Faults & Failures - 1/4

Fiber Gaps & incorrectly-cleaved fiber ends



Fiber Gap



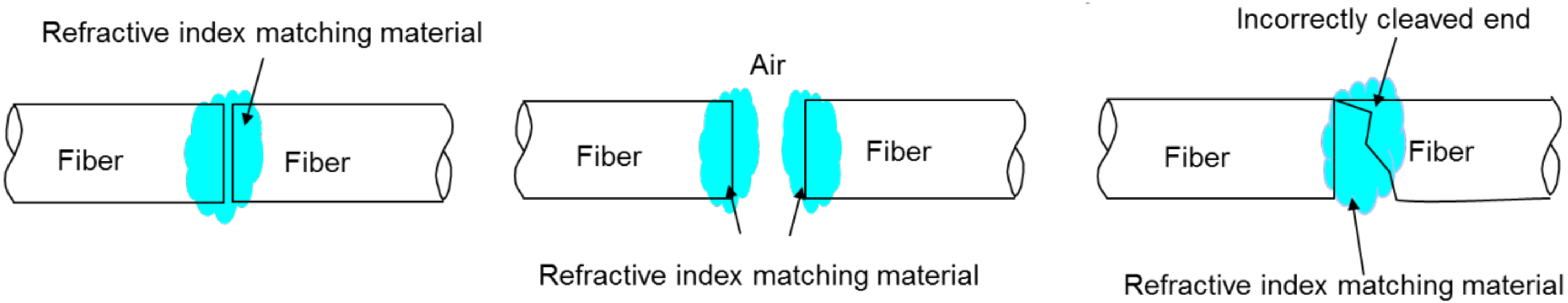
Incorrectly cleaved fiber ends

Actual defective field assembly connectors were collected from a service provider and checked for their optical characteristics and dismantled to identify the cause of the fault.

12% of faults were caused by increased losses due to incorrect cleaving of optical fibers.
An incorrectly cleaved fiber end is shown in above.

Main Causes of Faults & Failures – 2/4

Fiber connection with refractive index matching material



(a) (b) (c)

(a) shows the normal connection state with a narrow gap between flat fiber ends,
(b) shows an abnormal connection state with a wide gap between flat fiber ends
(c) shows an abnormal state with an incorrectly cleaved (uneven) fiber end.

Main Causes of Faults & Failures – 3/4

Examples of scratched optical fibers.

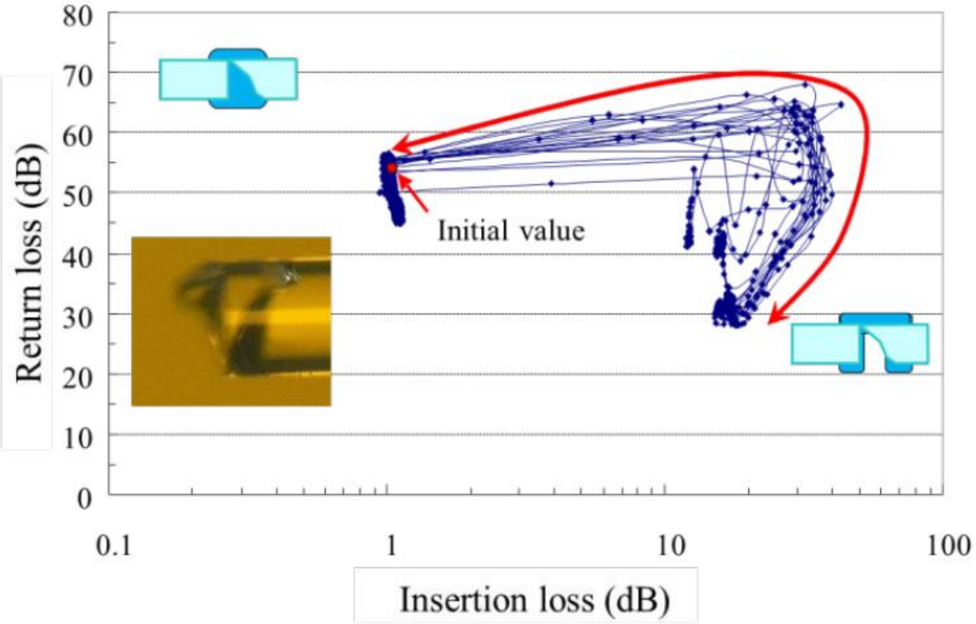
(a) Scratching caused by nipper blades

(b) Scratching caused by coating debris

Tools used to perform Mechanical Stripping are prone to scratching fibre strands and/or leaving debris.

Main Causes of Faults & Failures – 4/4

Scatter diagram results of heat cycle tests for fiber connections with incorrectly cleaved (uneven) fibers



The initial measurement for Insertion Loss (IL) was low at about 1 dB. The initial Return Loss (RL) was high at more than 40 dB. Over time, new field measurements of incorrectly cleaved fibers were recorded. Insertion Loss increased significantly, and Return Loss decreased as the temperature changed.

In the worst-case scenario, Insertion Loss changed to 43 dB and Return Loss changed to 28 dB.

Top Tips: Investing in Fusion Splicing

Recommendations:

1. Only Use Active Clad Alignment for Same-Era Fiber
2. Achieve Greater Accuracy with Core Alignment
3. Choose a Mass Fusion Splicer for Ribbon Fiber
4. Embrace the Variety of Applications
5. Easily Justify Your Investment.

Activities with Service Providers

Network Operations Center

OPEX SAVINGS!

CAPEX SAVINGS!

LET'S GET THE CONVERSATION STARTED

Broadband Access Infrastructure

Mobile x-Haul Solutions

LET'S GET THE CONVERSATION STARTED

Precision Deployment Tools

Fusion Splicers
(Active Clad-alignment, Ribbon, Core-alignment)

Fusion Splice-On Connectors
(FSOCs)

Fiber Splicing "Best Practices"

- Industry-adopted "Best Practices" include:
  1. Use Automatic Thermal Stripping (ATS) instead of Mechanical Fiber Stripping
  2. Standardize Fiber Cleaning and Inspection with every fiber splice
  3. Select a Precision Fibre Cleaving Tool with rotating blades
  4. Insist on automatic collection of fiber shards for Health & Safety
  5. Invest in Fusion Splicer Tools (i.e., Active Clad-alignment, Ribbon, Core-alignment)
  6. Use thermal shrink sleeves to protect Fusion splice points
  7. Standardize new FTTx applications with Fusion Splice On Connectors (FSOCs)
  8. Select FSOC back-boots designed for strain-relief (esp. FTTH)
  9. Match fiber optic glass types (i.e., avoid MFD mismatch)
  10. Deploy FSOCs: evolve Field Operation practices away from MSOCs.

Summary

1. **Service Providers continue to deploy fiber-based technologies for a variety of new broadband applications & services.**
   - Fusion Splicer Tools plus Fusion Splice On Connectors are important enabling tools
   - **Increase Field Ops productivity with "One & Done" approach to Precision Fiber Splicing**

2. **Seek out "Best Practices" for fiber splicing!**
   - Ask if free resources are available from your Suppliers

3. **Contact your FONEX + UCL Swift representatives for more information.**
   - Fusion Splicing Demos
   - Training Sessions

Thank you!

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