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FOA Technical Bulletin

Guide To Fiber Optic Installation

Contents

Part 1: Introduction

This FOA Technical Bulletin describes recommended procedures for installing and testing cabling networks that use fiber optic cables and related components to carry signals for communications, security, control and similar purposes. It defines a procedures that should provide a high level of quality for fiber optic cable installations. This document covers fiber optic cabling installed indoors (premises installations) with the addition of outside plant (OSP) applications involved in campus installations where the fiber optic cabling extends between buildings.

Reference Documents

This document is based on the FOA books (see references) and the FOA Online Reference Guide. You should also download a copy of the NECA/FOA 301 fiber optic installation standard as a reference.

There are other FOA Technical Bulletins that should be used as references for the design and planning of the network. These documents can be downloaded from the FOA Tech Topics website.

Guide To Fiber Optic Network Design, Tech Bulletin: What is fiber optic network design? This document covers the entire process from understanding fiber networks, choosing components, planning the network route and the installation process. It is an overview of the entire process. This document complements it in terms of addressing the details of the installation process.

User's Guide To Fiber Optics, Tech Bulletin: This Tech Bulletin answers many questions often asked by users of fiber optic networks and provides gideelines for their implementation. Should you use fiber optics for your communications system? What are its advantages and disadvantages? Is it hard to design and install fiber optic networks? Do they require maintenance?

Guide To Fiber Optic Network Restoration, Tech Bulletin. *What problems can be anticipated in planning fiber optic networks? How does the*
user determine the cause of the problem? How is the best and fastest way to restore communications?

Guide To Testing And Troubleshooting Fiber Optic Installation, Tech Bulletin. This is intended as an overview and installation checklist for all managers, engineers and installers on the overall process of testing and troubleshooting a fiber optic communications system.

Part 2: Planning for the install

Final planning for the installation is a critical phase of any project as it involves coordinating activites of many people and companies. The best way to keep everything straight is probably to develop a checklist based on the design path:

Pre-install checklist:

a) Main point of contact/project manager chosen
b) Link communications requirements set
c) Equipment requirements set and vendors chosen
d) Link route chosen, permits obtained
e) Cable plant components and vendors chosen
f) Coordination with facilities and electrical personnel complete
g) Documentation ready for installation, preliminary restoration plans ready
h) Test plan complete
i) Schedule and start date set for installation, all parties notified
j) Components ordered and delivery date set, plans made for receiving materials (time, place,) arrange security if left outside or on construction site
k) Contractor/installer chosen and start date set
l) Link route tour with contractor(s)
m) Construction plans reviewed with contractor(s)
n) Components chosen reviewed with contractor(s)
o) Schedule reviewed with contractor(s)
p) Safety rules reviewed with contractor(s)
q) Excess materials being kept for restoration reviewed with contractor(s)
r) Test plan reviewed with contractor(s)

Before starting the install:

a) All permits available for inspection
b) Sites prepared, power available
c) All components on site, inspected, security arranged if necessary
d) Contractor available
e) Relevant personnel notified
f) Safety rules posted on the job site(s) and reviewed with all supervisors and installation personnel

During The Installation:

a) Inspect workmanship
b) Daily review of process, progress, test data
c) Immediate notification and solution of problems, shortages, etc.

After completion of cable plant installation:

a) Inspect workmanship
b) Review test data on cable plant
c) Set up and test communications system
d) Update and complete documentation
e) Update and complete restoration plan
f) Store restoration plan, documentation, components, etc.

Part 3: Installation Requirements / General Guidelines

Receiving Fiber Optic Cabling and Equipment on Site

a) Fiber Optic equipment and components are subject to damage by improper handling and must be handled accordingly.

b) When initially received on the job site all fiber optic components should be carefully inspected for damage and tested for continuity or loss if damage is suspected.

c) Ensure that all components and parts have been shipped, received, match quantities ordered (e.g. fiber optic cable contains the number and type of fiber ordered and is the length ordered), and that any discrepancies or damaged goods are noted, the supplier notified and replaced as required.

d) All equipment and cabling shall be stored in a clean and dry location, protected from harsh environments and extremes of cold and heat.

Handling Fiber Optic Cables

a) Handle reels of fiber optic cable with care. All reels, regardless of size or length, must have both ends of the cable available for the testing. A fiber tracer or visual fault locator and bare fiber adapters can be used for continuity testing.

b) Move small, lightweight spools of fiber optic cable by hand. Move larger reels with appropriate lifting equipment or using two or more installers skilled in the moving operation.

c) Lifting equipment shall only must reels with a matched set of slings or chokers, attached to an appropriately sized piece of pipe inserted into the hole in the center of the reel. Slings and chokers shall never be attached around the spooled area of the reel. The cable reels shall be moved carefully to avoid damage to the cable.

Support Structures

a) Install support structures for fiber optic cable installations before the installation of the fiber optic cable itself. These structures should follow the guidelines of TIA/EIA 569 and NECA/BICSI 568.

b) Allow for future growth in the quantity and size of cables when determining the size of the pathway bend radius requirements.

c) Do not install a fiber optic cable in a conduit or duct that already contains cabling, regardless of the cable type. Existing or new empty ductwork can be modified to accept several different installations by the placement of innerduct within it.

Removal of Abandoned Cables

Unless directed by the owner or other agency that unused cables are reserved for future use, remove abandoned optical fiber cable (cable that is not terminated at equipment other than a connector and not identified for future use with a tag) as required by the National Electrical Code.

Fire Stopping

a) All telecommunications firestopping shall comply with applicable codes and standards, including TIA/EIA 569 and NECA/BICSI 568.

b) All penetrations shall be protected by approved firestops. Fire stopping compounds and devices shall be used whenever a fire separation has been breached by an installation.

c) In most geographical locals the breaching of a fire separation will require physical monitoring until it has been repaired.

d) Check with the “Authority Having Jurisdiction” for specific requirements on the project before commencing work.

Grounding and Bonding

a) Ground systems shall be designed as specified by the NEC and other applicable codes and standards (ANSI/TIA/EIA 607, NECA-BICSI-568).

b) Although most fiber optic cables are not conductive, any metallic hardware used in fiber optic cabling systems (such as wall-mounted termination boxes, racks, and patch panels) must be grounded.

c) Conductive cables require proper grounding and bonding for applicable conductors.

Part 4: Fiber Optic Components

Cables

Cable Types

Fiber optic cables are available in many types, for different applications. Premises cables are usually tight buffer designs that include jackets rated for flammability. OSP cables are generally loose tube designs with water blocking and may also have an armored jacket.

Some cables are usable for either OSP or premises applications. These include dry-water blocked tight buffered cables that can be used for short outdoor runs and double jacketed OSP cables that have a removable outside jacket and an inner jacket that is rated a flame retardant.

Fiber Optic Cables by Fiber Types

Fiber optic cables may contain multimode fibers, singlemode fibers or a combination of the two, in which case it is referred to as a "hybrid" cable. The type of cable shall be positively identified and , if hybrid, the type of each fiber, since multimode and singlemode fiber are terminated in different manners. See the section on termination below.

Fiber Optic Cables by Construction Type

a) Tight Buffered Cables

Tight buffered fiber optic cable contains fiber with a soft 900-micron diameter coating that protects the fiber and is color-coded for identification.

Simplex, Zip Cord: Tight buffered fibers are cabled with strength members (usually aramid fibers) in simplex or zip cord cables for use as patch cords.

Distribution: Multiple tight buffered fibers may be cabled with aramid fiber strength members and a central stiffener in a cable type called a distribution cable, often used for premises backbones, horizontal runs or general building cabling.

Breakout: Several simplex cables can be bundled in a single cable called a breakout cable.

Simplex, zipcord and breakout cables may be directly terminated for connection to a patch panel or network equipment as the cable provides adequate protection for the fibers.

Fibers in distribution cables are terminated directly, but the lack of protection for the individual fibers requires they be placed inside patch panels or wall-mounted boxes.

b) Loose Tube Cable

Loose tube (also called loose buffer) fiber optic cable consists of one or more protective tubes, each containing one or more fibers with only 250-micron primary coating over the fiber or ribbons typically containing 12 fibers per ribbon. Loose-tube cable is primarily used for outside plant installations where low attenuation and high cable pulling strength are required.

Many fibers can be incorporated into the same tube, providing a small-size, high-fiber density construction. The tubes are usually filled with a gel, which prevents water from entering the cable, although dry water-blocking compounds are becoming more common. The fibers in loose tube cables are protected from the outside environment and can be installed with higher pulling tensions than tight-buffered cables.

Fiber in loose tube cables may be spliced directly and placed in appropriate protective enclosures. Fibers in loose tube cables which have only the 250 micron primary coating should be sleeved with a break out kit for protection before termination and placed in patch panels or wall-mounted boxes for protection.

Ribbon Cable is a special type of cable that combines 12 or 24 fibers into a single ribbon. Ribbons can be cabled in loose tubes or in slots in a plastic core of the cable. Ribbon cables have typical fiber counts of 144, 288, 864 or more. Water blocking, armoring, etc. is done as with any loose tube cable.

Flammability - Cable Ratings and Markings

All premises cables shall be listed and have flammability ratings per NEC 770.50. Cables without markings should never be installed inside buildings, as they do not comply with the National Electrical Code. Optical cable markings are as follows:

OFN	optical fiber nonconductive
OFC	optical fiber conductive
OFNG or OFCG	general purpose
OFNR or OFCR	riser rated cable for vertical runs
OFNP or OFCP	plenum rated cables for use in air-handling plenums
OFN-LS	low smoke densitity

Color Codes: Fiber Optic Cable

Cable Jackets

Colors of cable jackets for identifying indoor fiber optic cable are not standardized. Typical colors are as follows:

Premises cables (Per TIA-598C):

Fiber Types	Color Codes		
	Non-Military	Military	Printed On Cable
Multimode (50/125) (OM2)	Orange	Orange	50/125
Multimode (50/125) (850 nm Laser-optimized) (OM3/4)	Aqua	Undefined	850 LO 50/125
Multimode (62.5/125) (OM1)	Orange	Slate	62.5/125
Multimode (100/140) (Obsolete)	Orange	Green	100/140
Single-mode OS1, OS2 (low water peak)	Yellow	Yellow	SM/NZDS or SM
Polarization Maintaining Single-mode	Blue	Undefined	Undefine

NOTES:

1) Natural jackets with colored tracers may be used instead of solid-color jackets.

2) Because of the limited number of applications for these fibers, print nomenclature are to be agreed upon between manufacturer and enduser

3) Other colors may be used providing that the print on the outer jacket identifies fiber classifications per subclause 4.3.3.

4) For some Premises Cable functional types (e.g., plenum cables), colored jacketing material may not be available. Distinctive jacket colors for other fiber types may be considered for addition to Table 3 at some future date.

Color Codes: Connectors
Since the earliest days of fiber optics, orange, black or gray was multimode and yellow singlemode. However, the advent of metallic connectors like the FC and ST made color coding difficult, so colored boots were often used. The TIA 568 color code for connector bodies and/or boots is **Beige** for multimode fiber, **Blue** for singlemode fiber, and **Green** for APC (angled) connectors.

Outside plant cables:

These are typically black to prevent UV radiation damage.

Some indoor cables are black or other colors. Refer to manufacturer's datasheets or cable jacket markings to determine the fibers in the cable.

Color Codes: Fiber
Fiber color codes are specified by TIA/EIA 598-A. In loose tube cables, this color code will be used for tubes as well as fibers within the tubes and sub-groups.

Fiber No.	Color
1	Blue
2	Orange
3	Green
4	Brown
5	Slate
6	White
7	Red
8	Black
9	Yellow
10	Violet
11	Rose
12	Aqua

Part 5: Installing Fiber Optic Cable

Fiber optic cable may be installed indoors or outdoors using several different installation processes. Outdoor cable may be direct buried, pulled or blown into conduit or innerduct, or installed aerially between poles. Indoor cables can be installed in raceways, cable trays, placed in hangers, pulled into conduit or innerduct or blown though special ducts with compressed gas. The installation process will depend on the nature of the installation and the type of cable being used.

Installation methods for both wire and optical fiber communications cables are similar. Fiber cable is designed to be pulled with much greater force than copper wire if pulled correctly, but excess stress may harm the fibers, potentially causing eventual failure.

Installation Guidelines

a) Follow the cable manufacturer's recommendations. Fiber optic cable is often custom-designed for the installation and the manufacturer may have specific instructions on its installation.
b) Check the cable length to make sure the cable being pulled is long enough for the run to prevent having to splice fiber and provide special protection for the splices.
c) Try to complete the installation in one pull. Prior to any installation, assess the route carefully to determine the methods of installation and obstacles likely to be encountered.

Pulling tension

a) Cable manufacturers install special strength members, usually aramid yarn, for pulling. Fiber optic cable should only be pulled by these strength members. Any other method may put stress on the fibers and harm them.
b) Swivel pulling eyes should be used to attach the pulling rope or tape to the cable to prevent cable twisting during the pull.
c) Cables should not be pulled by the jacket unless it is specifically approved by the cable manufacturers and an approved cable grip is used.
d) Tight buffer cable can be pulled by the jacket in premises applications if a large (~40 cm, 8 in.) spool is used as a pulling mandrel. Wrap the cable around the spool 5 times and hold gently when pulling.
e) Do not exceed the maximum pulling tension rating. Consult the cable manufacturer and suppliers of conduit, innerduct, and cable lubricants for guidelines on tension ratings and lubricant use.
f) On long runs (up to approximately 3 miles or 5 kilometers), use proper lubricants and make sure they are compatible with the cable jacket. If possible, use an automated puller with tension control and/or a breakaway pulling eye. On very long runs (farther than approximately 2.5 miles or 4 kilometers), pull from the middle out

to both ends or pull to intermediate points and figure 8 the cable then pull to the next point or use an automated fiber puller at intermediate point(s) for a continuous pull.

g) When laying loops of fiber on a surface during a pull, use “figure-8” loops to prevent twisting the cable.

Bend radius

a) Do not exceed the cable bend radius. Fiber optic cable can be broken when kinked or bent too tightly, especially during pulling.
b) If no specific recommendations are available from the cable manufacturer, the cable should not be pulled over a bend radius smaller than twenty (20) times the cable diameter.
c) After completion of the pull, the cable should not have any bend radius smaller than ten (10) times the cable diameter.

Twisting cable

a) Do not twist the cable. Twisting the cable can stress the fibers. Tension on the cable and pulling ropes can cause twisting.
b) Use a swivel pulling eye to connect the pull rope to the cable to prevent pulling tension causing twisting forces on the cable.
c) Roll the cable off the spool instead of spinning it off the spool end to prevent putting a twist in the cable for every turn on the spool.
d) When laying cable out for a long pull, use a "figure 8" on the ground to prevent twisting. The figure 8 puts a half twist in on one side of the 8 and takes it out on the other, preventing twists.

Vertical cable runs

a) Drop vertical cables down rather than pulling them up whenever possible.
b) Support cables at frequent intervals to prevent excess stress on the jacket. Support can be provided by cable ties (tightened snugly, not tightly enough to deform the cable jacket) or Kellems grips.
c) Use service loops can to assist in gripping the cable for support and provide cable for future repairs or rerouting.

Use Of Cable Ties

Fiber optic cables, like all communications cables, are sensitive to compressive or crushing loads. Cable ties used with many cables, especially when tightened with an installation tool, are harmful to fiber optic cables, causing attenuation and potential fiber breakage.

a) When used, cable ties should be hand tightened to be snug but loose enough to be moved along the cable by hand. Then the excess length of the tie should be cut off to prevent future tightening.

b) Hook-and-loop fastener ties are preferred for fiber optic cables, as they cannot apply crush loads sufficient to harm the cable.

Cable Plant Hardware

All premises hardware and support structures should follow the recommendations of TIA/EIA 569. Outside plant hardware and installation equipment should follow manufacturer's recommendations.

Cable Racks, Trays, Conduit and Innerduct

a) Outside plant cables can be installed underground in conduit or innerduct or direct buried, depending on the cable type. Aerial cable installation may use cables lashed to a support messenger cable or be self-supporting. Underwater cable installation must follow manufacturer's directions.
b) Premises cabling can be installed in cable trays, ladder racks, J-hooks, or other appropriate support structures.
c) Building cables can be installed directly, but installing them inside plenum-rated innerduct provides extra protection for the fiber cable. Innerduct is bright orange and will provide a good way to identify fiber optic cable and protect it from damage.

Fiber Optic Splicing and Termination Hardware

a) Breakout kits: The fibers in loose tube cables have only the 250 micron primary buffer coating. Use breakout kits to separate and protect individual fibers in a loose tube cable for termination directly on the fibers.
b) Splice enclosures: For long cable runs outside, splices are necessary to connect lengths of cable. Splices require protection that is provided by a sealed splice closure. Choose closures with adequate space for the number of fibers in the cables and port locations appropriate for the final mounting. Splice closures can be sealed and buried in the ground, placed in a vault or suspended aerially. Outside plant cables terminted in buildings may also need closures if they are terminated by splicing on pre-terminated pigtails as is common.
c) Splice panels and patch panels: Terminate or splice distribution cables inside panels or boxes to protect the fibers from damage. Boxes or panels may be rack- or wall-mounted. All should have locks to prevent unauthorized entry.
d) Racks and cabinets: Enclosures for patch panels and splice panels are used to terminate and organize cables. Use appropriate cable management hardware on the racks to route and separate cables to minimize potential for damage and facilitate moves, adds and changes.
e) Take care with all splicing and termination hardware to maintain cable bend radiuses, prevent pinching or kinking of fibers and separate fibers to allow for future restoration, moves or other work.

Part 6: Fiber Optic Termination

Fiber optic termination processes vary according to the types of fiber being terminated, the style of connectors or splices used and the termination process appropriate for that connector. Fiber optic cable can be terminated in two ways, using:

1) Connectors that mate two fibers to create a temporary joint and/or connect the optical fiber to network equipment.
2) Splices which create a permanent joint between two fibers.

The decision whether to use connectors or splices depends on the application. All terminations must be of the right style, installed in a manner that provides low light loss and back reflection and protected against the expected environment, dirt or damage while in use.

Choice of connector

Fiber optic connectors are manufactured in a number of different styles (e.g., ST, SC, LC, MT-RJ) that attach to the fibers in a fiber optic cable by a number of different methods (e.g., epoxy polish, prepolished/splice, etc.)

The connectors used in the cable plant being installed should:
1) Be compatible with the fiber optic cabling,
1) Be compatible with the equipment intended for use on the cabling
2) Provide adequate optical performance (loss and return loss)
3) Be compatible with the operating environment (temperature, humidity, etc.) of the installation and
4) Be compatible with like style connectors. All fiber optic connectors used should have a reference FOCIS document (Fiber Optic Connector Intermateability Standard) published by TIA/EIA.

Fiber optic connectors may be field installed by direct attachment to the cable or by splicing preterminated pigtails onto the installed cable. Multimode connectors are generally installed directly onto fibers in the field while singlemode cables are more likely to be terminated by splicing on preterminated pigtails.

Termination types

Several different types of terminations are available for optical fibers. Follow the manufacturer’s directions exactly for the termination process used to ensure best connector performance and reliability.

a) Adhesive Terminations
Many connectors use epoxies or other adhesives to hold the fiber in the connector. Use only the specified epoxy, as the fiber-to-ferrule bond is critical for low loss and long term reliability.

1. Epoxy/Polish: The fiber is glued into the connector with two-part epoxy and the end polished with special polishing film. This method provides the most reliable connection and lowest losses. The epoxy can be allowed to set overnight or cured in a special oven. A "heat gun" should not be used to cure the epoxy as the uneven heat may not cure all the epoxy or may overheat it which will prevent curing.
2. Hot Melt: This connector is similar to the epoxy/polish connector but already has the adhesive (a heat set glue) inside the connector. The adhesive is liquefied in an oven before the fiber can be inserted. The fiber is secured when the adhesive cools.
3. Anaerobic Adhesives: These connectors use a quick-setting adhesive instead of the epoxy. They may use a single part adhesive or an adhesive and setting agent. Some adhesives do not have the wide temperature range of epoxies, so they should only be used indoors unless otherwise specified.

b) Crimp/Polish or Crimp/Cleave Terminations
These connectors use a crimp on the fiber to hold it in the connector ferrule. The fiber can be polished like an adhesive connector or cleaved with a special tool. Ensure the crimp is made properly to prevent fiber pistoning (pulling back or pushing forward in the connector ferrule.)

c) Prepolished/Splice
These connectors have a short stub of fiber already epoxied into the ferrule and polished. Termination requires cleaving a fiber, inserting it into the back of the connector like a splice and crimping. The loss of these connectors will generally be higher than adhesive connectors, since they include a connector loss plus a splice loss in every connector. To achieve low loss, the fiber must be cleaved properly, which requires a good cleaver (prefereably the type used with fusion splicers) and good technique. Ensure the crimp is made properly to prevent fiber pistoning (pulling back in the connector ferrule.) The termination process can be monitored with a visual fault locator.

Termination process

a) Whichever process is used for termination, follow the manufacturer’s instructions carefully.
b) Use only adhesives approved by the manufacturer, and employ adhesive curing times in accordance with the manufacturer’s instructions.
c) When special tools are required, use them in the appropriate manner.
d) Once installation is completed, connectors should be covered with an appropriate dust cap and stored in a safe location awaiting testing or connection to network equipment.

Connector performance

Connector performance shall be within industry normal limits or as specified in TIA/EIA 568. Connector performance may be specified by end users at a different value, and if so, those values shall be used for acceptance. Since TIA 568 includes adhesive/polish and prepolished/splice connectors as well as multifiber connectors, the limit is set high to accommodate all types at 0.75 dB. Adhesive polish connectors will generally have losses well under 0.5 dB.

Performance verification

Following completed installation and termination, all terminated cables must be tested. The section on testing below provides more detail on testing requirements at the conclusion of installation.

a) Examine all connectors requiring polishing with a microscope for proper end finish, cracks, scratches or dirt per FOTP-57.
b) Test all fibers in all cables for loss using an OLTS power meter and source. Test multimode cables using TIA/EIA 526-14, and singlemode cables using TIA/EIA 526-7 (single mode). Total loss shall be less than the calculated maximum loss for the cable based on appropriate standards or customer specifications as determined in a loss budget analysis done in the design phase.

Fiber polarization/End To End Connections

In fiber networks, separate fibers are typically used for transmission in each direction, therefore it is necessary to identify the fiber connected to the transmitter and receiver at each end.

a) Duplex connectors such as the duplex SC or MT-RJ are polarized, that is they are keyed to allow connection in only one orientation. Follow the polarization rules given in TIA/EIA 568-B3, Section 5.2.4.
b) Simplex connectors should be documented for connections and when allocated to the transceiver of networking equipment, marked for transmit and receive at each end of the link.

Fiber Optic Splices

Types of splices

Splices are a permanent joint or connection between two fibers. There are two basic types of splices, fusion and mechanical.

a) Fusion Splices
   These "weld" the two fibers together usually in an electric arc. Fusion splicers are generally automated and produce splices that have minimal losses. Fusion splicing should not be performed in a dusty or explosive atmosphere as the electric arc may cause an explosion or fire.

b) Mechanical Splices

These align two fibers in a ferrule or v-groove with index-matching gel or adhesive between the fibers to reduce loss and back reflection. Mechanical splices are used for temporary restoration as well as permanent joints.

Splice performance

Splice performance shall be within industry accepted limits or as specified in TIA/EIA 568. While TIA-568 specifies 0.3 dB loss for both multimode and singlemode splices, singlemode fusion splices are typically under 0.1 dB. If splice performance may be specified by end users at a different value, and if so, those values shall be used for acceptance.

Splice performance verification

End-to-end tests of fiber optic cable loss include the losses caused by splices. If the cable loss exceeds the calculated maximum value, or if the customer requires splice loss verification, test the cable with an OTDR to analyze the loss of individual components (fiber, connectors, and splices) in the cable. Test splice loss in both directions and average the measured values to reduce the directional effects of OTDR measurements.

Part 7: Testing the Installed Fiber Optic Cable Plant

During the design phase, each cable run should have a "Loss Budget" calculated based on component specifications. After installation, test each fiber in all fiber optic cables for verification of proper installation by comparing measured loss to the calculated loss from the Loss Budget. Perform the following tests:

a) Visual Inspection and cleaning of connectors.
b) Continuity testing to determine that the fiber routing and/or polarization is correct and documentation is proper.
b) End-to-end insertion loss using an OLTS power meter and source. Test multimode cables using TIA/EIA 526-14, and singlemode cables using TIA/EIA 526-7 (single mode). Total loss shall be less than the calculated maximum loss for the cable based on Loss Budget calculations using appropriate standards or customer specifications.
c) Optional OTDR testing may be used to verify cable installation and splice performance. However, OTDR testing should not be used to determine cable loss, especially on longer cables. Use of an OTDR in premises applications may be inappropriate if cables are too short.
d) If the design documentation does not include cable plant length, and this is not recorded during installation, read the length from the distance markingd on the cbale jacket or test the length of the fiber using the length feature available on an OTDR, or some OLTSs.
e) If testing shows variances from expected losses, troubleshoot the problems and correct them.

Standards

- FOA Standard FOA-1: Testing Loss of Installed Fiber Optic Cable Plant, (Insertion Loss, TIA OFSTP-14, OFSTP-7, ISO/IEC 61280, ISO/IEC 14763, etc.)
- FOA Standard FOA-2: Testing Loss of Fiber Optic Cables, Single Ended, (Insertion Loss, TIA FOTP-171, OFSTP-7, , ISO/IEC 14763)
- FOA Standard FOA-3: Measuring Optical Power (Transmitter and Receiver Power, FOTP-95, Numerous ISO/IEC standards)
- FOA Standard FOA-4: OTDR Testing of Fiber Optic Cable Plant (TIA FOTP-8/59/60/61/78, ISO/IEC 14763, etc.)
- FOA Standard FOA-5 Fiber Optic Datalinks

Tools and Test Equipment

The following tools are needed to test and troubleshoot the fiber optic cable plant, system or link properly.

a. Optical Loss Test Set or power meter and test source with optical ratings matching the specifications of the installed system (fiber type and transmitter wavelength and type) and proper connector adapters. An OLTS that merely tests cable plant loss may not include a calibrated power meter needed for testing transmitter and receiver power, so a calibrated power meter and source are a better choice for link or system testing.

b. Reference test cables with proper sized fiber and connectors and compatible mating adapters of known good quality. These do not generally need to be "reference quality" but only in good condition, generally defined as having connector losses of less than 0.5 dB.
c. Visual fiber tracer and/or visual fault locator (VFL)
d. Connector inspection microscope with magnification of 100-200X and fixturing for proper connectors. Video microscopes are recommended.
e. Cleaning supplies intended specifically for the cleaning of fiber optic connectors.
f. Optional: OTDR with long launch and receive cables (100 m for Multimode, 1 km or more for singlemode)

Connector Inspection And Cleaning

Inspect and clean fiber optic connectors before testing. Visual inspection of connectors with a microscope allows confirmation that installation was properly done and connectors are clean before testing. Proper inspection requires a microscope with fixturing for fiber optic connectors and a magnification of 100-200X. Higher magnification may be too high for inspection. Video microscopes are preferred because they are easier to use and photos of the connector end may be saved for later reference.

Before any testing, connectors should be cleaned carefully to ensure that no dirt is present on the end face of the connector ferrule as this will cause high loss and reflectance. Protective caps on connectors, often called "dust caps" – some say that's because they usually contain dust – do not necessarily keep connectors clean. Use cleaning supplies intended for cleaning fiber optic connecotrs only as other materials my leave residue or cause harm to the connectors.

Continuity Testing

Perform continuity testing of optical fibers using a visual fiber tracer, visual fault locator, or OLTS power meter and source. Trace the fiber from end to end through any interconnections to ensure that the path is properly installed, and that polarization and routing are correct and documented.

Insertion Loss

Insertion loss refers to the optical loss of the installed fibers when measured with a test source and power meter (OLTS). Test multimode cables using TIA/EIA 526-14, and singlemode cables using TIA/EIA 526-7 (single mode).

a) Test multimode fiber at 850 and 1300 nm, and singlemode fiber at 1310 and 1550 nm, unless otherwise required by other standards or customer requirements.
b) Test reference test cables to verify quality and clean them often.
c) Cabling intended for use with high speed systems using laser sources may be tested with appropriate laser sources to ensure that tests verify performance with that type of source.

OTDR Testing

The optical time domain reflectometer (OTDR) uses optical radar-like techniques to create a picture of a fiber in an installed fiber optic cable. The picture, called a signature or trace, contains data on the length of the fiber, loss in fiber segments, connectors, splices and loss caused by stress during installation.

OTDRs are used to verify the quality of the installation or for troubleshooting. However, OTDR testing shall not be used to determine cable loss.

OTDRs have limited distance resolution and may show confusing artifacts when testing short cables typical of premises applications. If OTDR testing of premises cables is desired, experienced personnel should evalute the appropriateness of the tests.

OTDR testing should only performed by trained personnel, using certified equipment designed for the purpose. The technicians performing the tests should be trained not only in operation of the OTDR equipment, but also in the interpretation of OTDR traces. *Untrained personnel using OTDRs improperly are the biggest cause of problems in fiber optic testing*.

Part 8: Administration, Management, and Documentation

Documentation of the fiber optic cable plant is an integral part of the design, installation and maintenance process for the fiber optic network. Documenting the installation properly will facilitate installation, allow better planning for upgrading, simplify testing and future moves, adds and changes.

Documentation of the fiber optic cable plant should follow ANSI/TIA/EIA-606, Administration Standard for the Telecommunications Infrastructure of Commercial Buildings.

Fiber optic cables, especially those used for backbone cables, may contain many fibers that connect a number of different links going to several different locations with interconnections at patch panels or splice closures. The fiber optic cable plant should be documented as to the exact path that every fiber in each cable follows, including intermediate connections and every connector type.

Documentation should also include insertion loss data and optional OTDR traces.

Part 9: References

There are other FOA Technical Bulletins that should be used as references for the design and planning of the network. These documents can be downloaded from the FOA Tech Topics website. In addition to those, we recommend:

The FOA Reference Guide to Fiber Optics

The FOA Reference Guide to Fiber Optic Testing

The FOA Reference Guide to Fiber Optic Network Design

The FOA Reference Guide to Premises Cabling

The FOA Reference Guide to Outside Plant Fiber Optics

FOA Online Reference Guide, FOA website, www.thefoa.org

NECA/FOA-301 Standard For Installing And Testing Fiber Optic Cables
(NECA/FOA-301), *Download from FOA website*

FOA Tech Bulletins (Printable Reference Documents)
Designing and manufacturing fiber optic communications products for manufacturers of products using fiber optics . (PDF, 0.2 Mb)
Choosing, installing and using fiber optic products for communications network users. (PDF, 0.1 Mb) (this document)
Designing Fiber Optic Networks - for contractors, designers, installers and users and the reference for the FOA CFOS/D Design Certification (PDF, 1.3 MB).
Installing Fiber Optic Cable Plants. (PDF, 0.2 Mb)
Troubleshooting fiber optic cable plants and communications systems. (PDF, 0.1 Mb)
Fiber Optic Restoration - how to plan ahead and restore networks quickly. (PDF, 0.1 Mb)

Note: This information is provided by The Fiber Optic Association, Inc. as a benefit to those interested in designing, manufacturing, selling, installing or using fiber optic communications systems or networks. It is intended to be used as a overview and guideline and in no way should be considered to be complete or comprehensive. These guidelines are strictly the opinion of the FOA and the reader is expected to use them as a basis for creating their own documentation, specifications, etc. The FOA assumes no liability for their use.

Do you have comments on this technical bulletin, corrections or information to add to it to make it more complete. Please send them to the FOA at info@foa.org.

The Fiber Optic Association, the professional society of fiber optics, has available on its website, www.foa.org, guides for end users on fiber optic network design and *installation. The FOA also has a website offering free online self-study programs, www.fiberu.org.*

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