

Standard for Installing & Testing

Fiber Optic Cables



Published by
National Electrical
Contractors Association



Jointly developed with
Fiber Optic Association



NECA/FOA 301–1998

Standard for

Installing and Testing Fiber Optic Cables

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**National Electrical
Contractors Association**



Jointly developed with
The Fiber Optic Association



National Electrical Installation Standards™

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(This foreword is not a part of the standard)

Foreword

National Electrical Installation Standards™ are designed to improve communication among specifiers, purchasers, and suppliers of electrical construction services. They define a minimum baseline of quality and workmanship for installing electrical products and systems. *NEIS™* are intended to be referenced in contract documents for electrical construction projects. The following language is recommended:

Fiber optic cables shall be installed in accordance with NECA/FOA 301, *Standard for Installing and Testing Fiber Optic Cables*.

Use of *NEIS™* is voluntary, and neither the National Electrical Contractors Association nor the Fiber Optic Association assumes any obligation or liability to users of this publication. Existence of a standard shall not preclude any member or nonmember of NECA or FOA from specifying or using alternate construction methods permitted by applicable regulations.

The installation and maintenance practices recommended by this publication are intended to comply with the edition of the National Electrical Code® (NEC) in effect at the time of publication. *NEIS™* are not intended to duplicate NEC requirements nor to establish regulatory requirements for electrical construction. It is the responsibility of users

of this standard to comply with state and local electrical codes when installing electrical products and systems.

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1. Scope

This standard describes procedures for installing and testing fiber optic cables and related components to carry signals for telecommunications, control, and similar purposes. These procedures represent a minimum level of quality for fiber optic installations. This standard is intended to define what is meant by installing equipment in a “neat and workmanlike manner” as required by the National Electrical Code, Sections 110-12 and 770-8.

All information in this publication is intended to comply with the following standards. Installers should always follow the NEC, NESC, applicable state and local codes, and manufacturers’ instructions when installing fiber optic products and systems.

ANSI/NFPA 70, *National Electrical Code*

ANSI/IEEE C2, *National Electrical Safety Code*

ANSI/TIA/EIA-568A, *Commercial Building Telecommunications Standard*

ANSI/TIA/EIA-590, *Standard for Physical Location and Protection of Below Ground Fiber Optic Cable Plant*

ANSI/TIA/EIA-569A, *Telecommunications Wiring Pathways and Spaces*

ANSI/TIA/EIA-606, *Telecommunications Cabling System Administration*

ANSI/TIA/EIA-607, *Telecommunications System Grounding and Bonding*

2. Definitions

All-Dielectric Self-Supporting Optical Cable (ADSS)	An optical cable with sufficient strength to support its own weight plus wind and ice loadings for spans between supporting structures.	Bending Loss Microbending Loss	Loss in fiber caused by stress on the fiber bent around a restrictive radius.
Attenuation	The reduction in optical power as it passes along a fiber, usually expressed in decibels per kilometer (dB/km). See <i>optical loss</i> .	Bit	An electrical or optical pulse that carries information. The term bit means <i>binary digit</i> .
Attenuator	A device that reduces signal power in a fiber optic link by inducing loss.	Buffer	A protective coating applied directly to the fiber.
Average Power	The average power of a light signal (in dBm) over time of a modulated signal.	Cable	One or more fibers enclosed in protective coverings and strength members.
Back Reflection, Optical Return Loss	Light reflected from the cleaved or polished end of a fiber caused by the difference of refractive indices of air and glass. Typically, back reflection is less than 4% of the incident light, depending on termination technique. Expressed in dB relative to incident power. See <i>fresnel reflection</i> .	Cable Plant, Fiber Optic	The combination of fiber optic cable sections, connectors and splices forming the optical path between two terminal devices.
Backscattering	The scattering of light in a fiber back toward the source, used to make OTDR measurements.	CATV	Community Antenna Television or cable TV.
Bandwidth	The range of signal frequencies or bit rates within which a fiber optic component, link, or network will operate.	Chromatic Dispersion	The temporal spreading of a pulse in an optical waveguide caused by the wavelength dependence of the velocities of light.
		Cladding	The lower refractive index optical cladding over the core of the optical fiber that reflects light back into the core.
		Cleaving	A method of cutting optical fibers by scoring and bending them, causing them to break along the scoring line.

Composite Cable	A cable containing both optical fibers and electrical conductors.	Ferrule	A precision tube which holds a fiber for alignment for interconnection or termination. A ferrule may be part of a connector or mechanical splice.
Conductive Cables	Optical cables containing metallic members that can become energized.	Fiber Optics	Light transmission through flexible transmissive fibers for communications or lighting. Also called <i>fiberoptics</i> and <i>fiber-optics</i> , see also <i>optical fiber</i> .
Connector	A demountable device that connects two fibers, or a fiber and an active device, and that protects the fiber.	FO	Common abbreviation for <i>fiber optic</i> .
Connectorization	Preparation of the end of a fiber to allow connection to another fiber of an active device. Also called <i>termination</i> .	Fresnel Reflection	Light reflected from the cleaved or polished end of a fiber caused by the difference of refractive indices of air and glass. Typically, this is less than 4 percent of the incident light, depending on termination technique. See <i>back reflection</i> .
Core	The center of the optical fiber through which light is transmitted.	Fusion Splicer	An instrument that splices fibers by fusing or welding them, typically by electrical arc.
dBμ	Optical power, expressed in decibels referenced to 1 microwatt.	Graded Index	A type of multimode fiber that used a graded profile of refractive index in the core material to correct for modal dispersion.
dBm	Optical power, expressed in decibels referenced to 1 milliwatt.	Hybrid Cable	A single optical cable containing two different types of optical fibers.
Decibel (dB)	A unit of measurement of optical power indicating relative power on a logarithmic scale.	Index of Refraction	A measure of the speed of light in a material.
Detector	A photodiode that converts optical signals to electrical signals.		
Dispersion	The temporal spreading of a pulse in an optical fiber, caused by modal or chromatic effects.		
End Finish	The quality of the end surface of a fiber prepared for splicing or termination in a connector.		

Index Matching Fluid	A liquid with a refractive index similar to glass. Used to match the materials at the end of two fibers to reduce loss and back reflection.	Light-emitting Diode, LED	A semiconductor device that emits light when stimulated by an electrical current. Used in transmitters for multimode fiber links.
Index Profile	The refractive index of a fiber as a function of cross section.	Link, Fiber Optic	A transmitter and receiver connected by fiber optic cable, capable of transmitting data.
Innerduct	A type of fire-resistant plastic tubing, usually of a small size (1-inch inner diameter being typical), used in a variety of ways for the installation and protection of optical cables.	Loss, Optical	The amount of optical power lost as light is transmitted through fiber, splices, couplers, or other components in an optical fiber system.
Insertion Loss	The loss caused by the insertion of a component such as a splice or connector in an optical fiber.	Loss Budget	The amount of power lost in the link. Often used in terms of the maximum amount of loss that can be tolerated within a given link.
Jacket	The protective outer coating of the cable.	Mechanical Splice	A semi-permanent connection between two fibers made with an alignment device and index matching fluid or adhesive.
Jumper Cable	A short single fiber cable with connectors on both ends used for interconnecting other cables or for testing.	Micron (μ)	A unit of measure, 10^{-6} meters, used to measure the diameter of an optical fiber. Also called a micrometer.
Laser Diode	A semiconductor device that emits high powered, coherent light when stimulated by an electrical current. Used in transmitters for singlemode fiber links.	Microscope, Fiber Optic Inspection	A microscope used to inspect the end surface of a connector for flaws or contamination, or a fiber for cleave quality.
Launch Cable	A known good fiber optic jumper cable attached to a source and calibrated for output power used for loss testing. This cable must be made of fiber and connectors of a matching type to the cables to be tested.	Multimode Fiber	A fiber with core diameter much larger than the wavelength of light transmitted, allowing many modes of light to propagate. Commonly used with LED sources for lower speed, short distance links.

Nanometer (nm)	A unit of measure, 10^{-9} meters, used to measure the wavelength of light.	Optical Time Domain Reflectometer (OTDR)	An instrument that uses backscattered light to find faults in optical fibers and to infer loss.
Network	A specifically configured system of cables, hardware, and equipment used for voice, video, and/or data communications.	Outside Plant Cables	Cables intended for use outside buildings in aerial, buried, or duct locations.
Optical Fiber	An optical waveguide, comprised of a light carrying core and reflective cladding that traps light in the core.	Pigtail	A short length of fiber attached to a fiber optic component such as a connector, laser, or coupler.
Optical Fiber Adaptor	A mechanical termination device designed to align and join optical fiber connectors.	Power Budget	The difference, in dB, between the transmitted optical power and the receiver sensitivity.
Optical Fiber Groundwire (OFGW)	An optical cable with outer layers of metallic wires, suitable for use as lightning protection shield wires on high-voltage utility lines.	Power Cables (or Power Wiring)	As used in this document, refers to common types of 60 Hz wiring for lighting and power, operating at a minimum of 120 volts ac (rms).
Optical Loss Test Set (OLTS)	A measurement instrument for optical loss that includes both a meter and source.	Power Meter, Fiber Optic	An instrument that measures optical power emanating from the end of a fiber.
Optical Power	The amount of radiant energy per unit time, expressed in linear units of Watts or on a logarithmic scale, in dBm (where 0 dB = 1 mW).	Premises Cable	Cable intended for use in buildings, requiring appropriate fire ratings and listing.
Optical Return Loss, Back Reflection	Light reflected from the cleaved or polished end of a fiber caused by the difference of refractive indices of air and glass. Typically less than 4 percent of the incident light, depending on termination technique. Expressed in dB relative to incident power.	Singlemode Fiber	A fiber with a small core, only a few times the wavelength of light transmitted, that allows only one mode of light to propagate. Commonly used with laser sources for high speed, long distance links.
		Source	A laser diode, LED, or other light sources used to inject an optical signal into fiber.

Splice (Fusion or Mechanical)	A device that provides for a connection between two fibers, typically intended to be permanent.	Visual Fault Locator	A device that couples visible light into the fiber to allow visual tracing and testing of continuity. Some are bright enough to allow finding breaks in fiber through the cable jacket.
Step Index Fiber	A multimode fiber in which the core has a single index of refraction.	Watts	linear measure of optical power, usually expressed in milliwatts (mW), microwatts (μ W), or nanowatts (nW).
Termination	Preparation of the end of a fiber to allow connection to another fiber or an active device. Also called <i>connectorization</i> .	Wavelength	A measure of the color of light, usually expressed in nanometers (nm) or microns (μ m).
Test Kit	A kit of fiber optic instruments, typically including a power meter, source, and test accessories used for measuring loss and power.		
Test Source	A laser diode or LED used to inject an optical signal into fiber for testing loss of the fiber or other components.		

3. Optical Fiber Cables, General Types

In almost all cases, optical fibers are contained in cables. Optical fibers though proportionally strong (having better tensile strength than steel), are of extremely small size, and must be enclosed in protective cabling.

Optical cables have several basic components, including the coated fiber itself, a tight buffer or loose-tube buffer (protective layer), a core structure of ribbons, loose tubes, or fiber bundles; a strength member system (aramid yarn, fiberglass rod, or other); a protective armor (for outside plant cables), and an outer jacket. Various types of buffers, strength members, and outer jackets can be combined to create cables suited to many different environments and uses, such as indoor cables, direct-burial cables, breakout cables, unitube cables, aerial cables, and others.

Figure 1 shows a cross-section of a simple tight-buffer cable. Figure 2 shows a cross-section of a simple loose-tube cable. Figure 3 shows a modified type of loose tube cable called a ribbon cable; this construction has the advantage of accommodating a high number of fibers in a fairly small cable. Note that these are simply examples of three basic cable types; there are many other types of cable configurations.

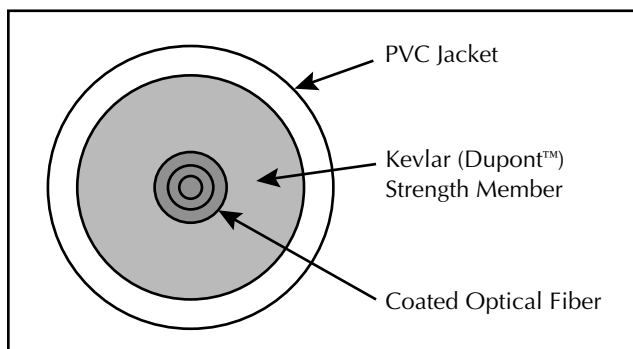


Figure 1: Cross-section of a simple tight-buffer cable.

Optical cables shall never be tightly bent, kinked, or looped in radii smaller than the manufacturer's stated limits. Cables that have been bent beyond their minimum bend radius shall be inspected for damage, and shall be removed, discarded, and replaced where necessary. All such over-bends shall be eliminated.

Optical cables shall not have more tension applied to them than the manufacturer's stated limits. They shall also be pulled by the methods specified by the manufacturer. See Pulling Fiber Optic Cables in Chapter 4.

3.1 Nonconductive, Conductive and Composite Cables

The three primary types of fiber optic cables are *non-conductive*, *conductive* and *composite*. It is necessary to make these distinctions because the different cable types pose different potential hazards.

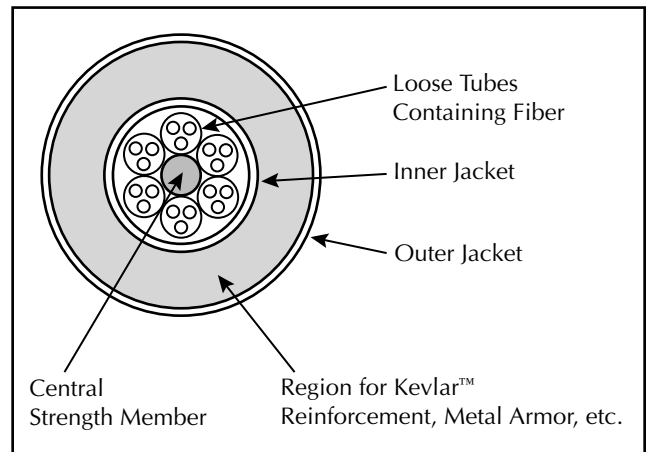


Figure 2: Cross-section of a simple loose-tube cable.

Nonconductive Cables

Nonconductive fiber optic cables contain no electrically conductive materials, and thus cannot become inadvertently energized. Such cables are also referred to as *all-dielectric* or *non-metallic*.

Conductive and Composite Cables

Conductive and composite cables both contain metallic members that can become energized.

Conductive cables contain both optical fibers and non-current carrying metallic members such as strength members, vapor shields, and metallic cable armor.

Composite cables contain both optical fibers and electrical conductors. These may be power conductors, usually in fairly small sizes such as No. 12 AWG,

or low voltage conductors such as twisted pairs for communications or signaling.

3.2 Loose Tube Cables

Loose tube cables are well-suited to long underground installations and to medium to high fiber counts. They may be installed indoors as well if they are appropriately fire rated, or are enclosed in an appropriate raceway system.

3.3 Tight Buffer Cables

Tight buffer cables (also called tight-tube cables) are particularly suited to indoor runs. They may be installed out of doors or directly buried if appropriately rated. Figures 4 and 5 show simple forms of the two most common types of tight buffer cables: simplex and duplex (zipcord). Note that these are simple examples of these cable types; there are many other cable configurations.

3.4 Central Core Tube-Ribbon or Fiber-Bundle Cables

Central core tube cables (having either ribbon stack or fiber bundle cores) are suited to installations where future splicing will be required. When rated for such use, they may be installed indoors or outdoors. Central core cables may be installed where subject to long-term vibrations.

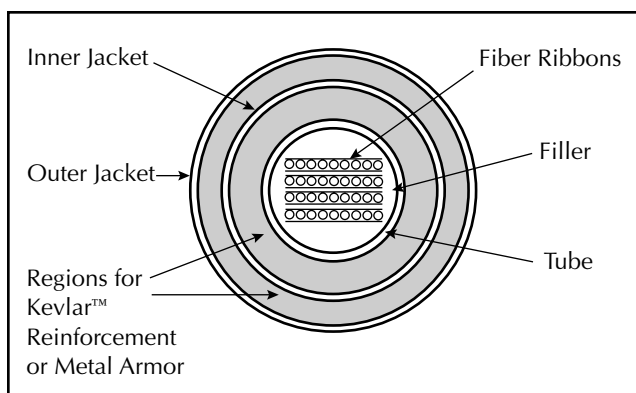


Figure 3: Modified type of loose-tube cable called a ribbon cable.

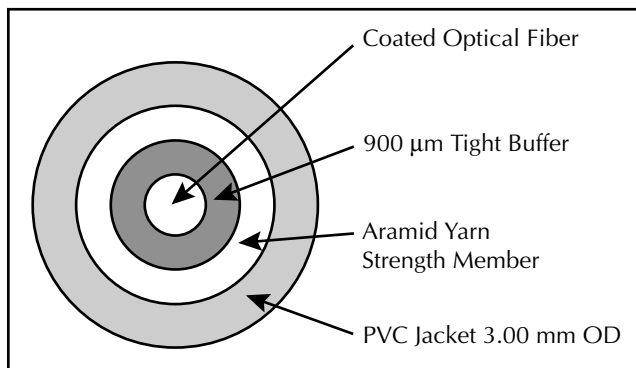


Figure 4: A simple form of a tight-buffer cable (simplex).

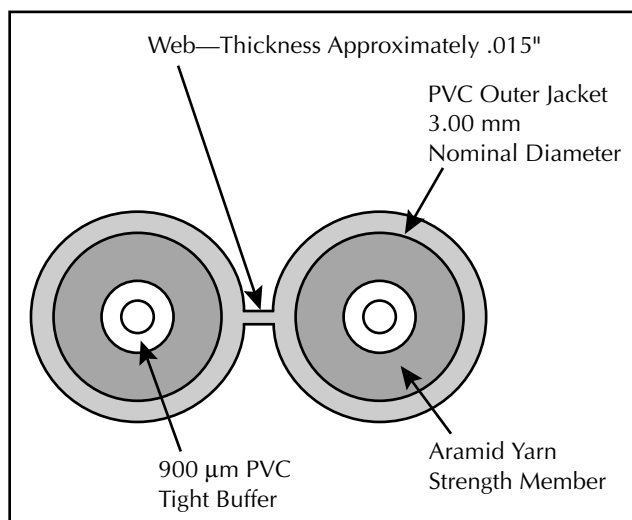


Figure 5: A simple form of a tight-buffer cable (duplex).

4. Cable Installation Procedures

All fiber optic cables should be installed in accordance with their listings and manufacturers' instructions.

4.1 Cable Supports

All optical cables shall be securely supported, and shall have the supports spaced closely enough that there will be no excessive force placed on the cable. In general, horizontal indoor cables shall be supported at intervals not exceeding three feet (91 cm). Supports may be placed up to 5 feet (1.52 m) apart for armored cables or cables greater than 0.5 inch (13mm) in diameter. Cables directly buried require no additional support. Cables in raceways are considered to be adequately supported by the raceway (see Figure 6).

Tightness Of Supports

All straps or supports placed on fiber optic cables shall be tight enough to hold the cable securely, but shall not be tight enough to substantially deform the shape

of the cable. When optical cables are squeezed out of shape, unacceptable forces are placed on the fibers, which frequently result in microbends, microcracking, or even broken fibers. Where possible, rounded or padded supports shall be used. Cable ties shall not be cinched too tightly, and shall have the free tab cut off, to prevent over-tightening in the future.

4.2 Protection

All optical cables shall be protected from physical damage.

No supplemental protection shall be required for cables installed in locations where they are unlikely to be accessed except by qualified personnel. When optical cables are installed in areas that are subject to damage, they shall be contained in a metal raceway, solid-bottom metal cable tray, solid metal cable tray with covers, or in schedule 80 rigid nonmetallic conduit.

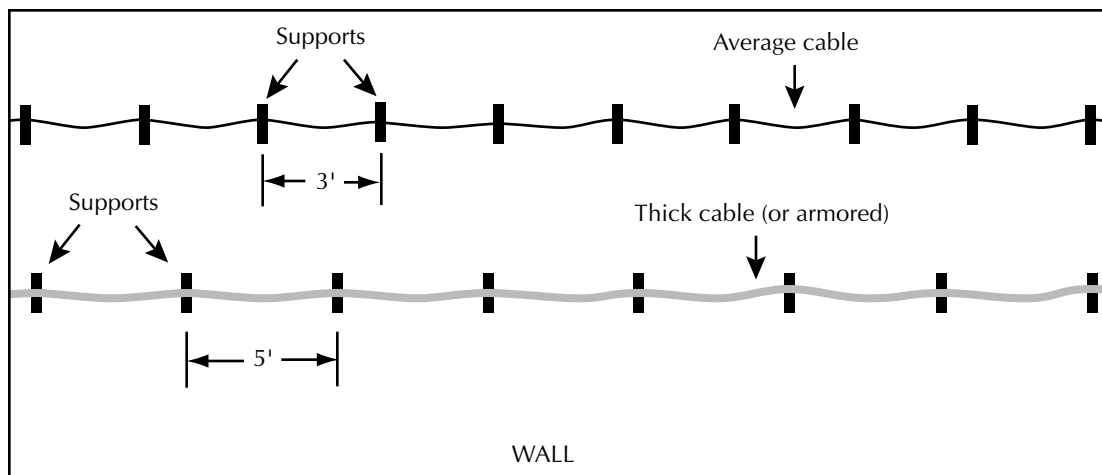


Figure 6: Supporting optical fiber cables.

4.3 Cable Organization and Marking

All optical cables shall be installed neatly. Where it is necessary to put optical cables in the same ceiling space, vault, cable tray, or similar location with other types of cables, the optical cables shall be contained in a separate and clearly marked innerduct.

Identification tags shall be placed on cable or innerduct at every readily accessible location. Cable installed in cable trays need be marked only at their ends. Cable tags shall be of permanent construction (for example, plastic cards), shall be indelibly marked, and shall include the following information:

- a) Fiber types and sizes.
- b) Details of the cable's path and termination points.
- c) Who owns or is responsible for the cable.
- d) Optional information, such as cable length or cable manufacturer.

4.4 Cable Jackets

Cable jackets shall be suited to the location in which they are installed.

When cables will be repetitively bent, they shall have a suitable outer jackets. Cables installed outdoors

shall be rated "UV resistant" or "UV stable". Such cables (outside plant cables) typically have black polyethylene outer jackets.

4.5 Fire Ratings And Applications

All optical cables installed in plenums or other areas handling environmental air shall be as plenum-rated (OFNP or OFCP). See Section 300-22 of the National Electrical Code.

Where optical cables extend into or through fire-rated walls, ceilings, or assemblies, the penetration shall be appropriately sealed and the assembly returned to its original fire rating.

Cable with higher fire-resistance ratings may generally be substituted for those with lower ratings. Substitutions of cable types shall be according to Section 770-53 of the National Electrical Code (*see Figure 7*).

Cables installed vertically between floors in a building shall be rated as riser or plenum cable.

4.6 Pulling Fiber Optic Cables

Always follow manufacturers' procedures when pulling fiber optic cables into raceways, cable trays, ducts, and enclosures. The following general procedures shall be followed when manufactures' procedures are not available:

- a) When pulling optical cables into conduits, cable trays, or raceways, the strength member(s) of the cable shall bear all or nearly all of the pulling force. Cable jackets shall not be directly pulled unless designed for the purpose, or unless the run is very short and requires a minimal pulling force. Optical cables shall not be pulled into place by applying tension directly to the fibers.
- b) Optical cables shall be attached to a pulling line only by methods recommended by the manufacturer of the cable.
- c) Cable pulling shall generally be done by hand.

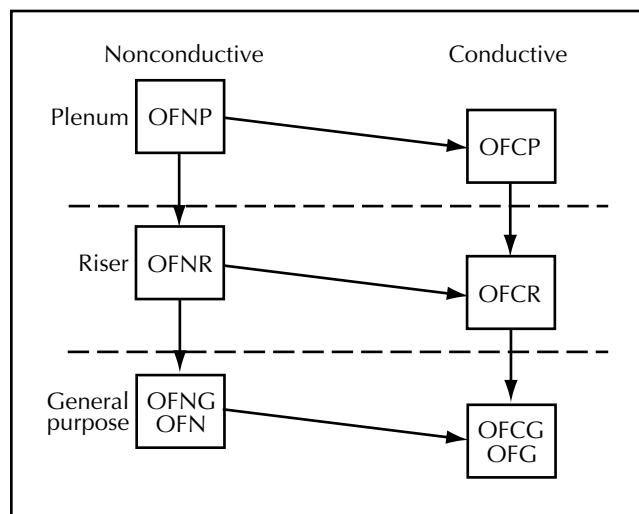


Figure 7: Substitutions of higher fire-resistance ratings to lower ratings.

d) When powered pulling equipment is used to install optical cable, tension monitoring equipment or break-away swivels shall be used. Swivels shall be used when pulling optical cables into conduits. Exceptions shall be made to this requirement only for very short runs which require a minimum pulling force.

e) Unless stated otherwise by the cable manufacturer, the maximum pulling tensions used for optical cables shall be 300 pounds (136 kg) for multi-fiber indoor cables, and 600 pounds (273 kg) for outdoor cables. The pulling force shall be uniform and consistent; cables shall not be jerked.

f) Continuous cable pulls shall be used whenever possible, avoiding splice points.

g) Boxes used with optical cables shall be designed for the purpose, and shall be equipped with cable supports. Pull boxes shall be sized so that no cables in the box are tightly bent.

h) A length of free cable shall be provided at each end of a cable pull. Loops of cable (commonly called *service loops*) shall be provided at all intermediate pulling points, such as in manholes and pull boxes. The cable's minimum bending radius shall not be violated.

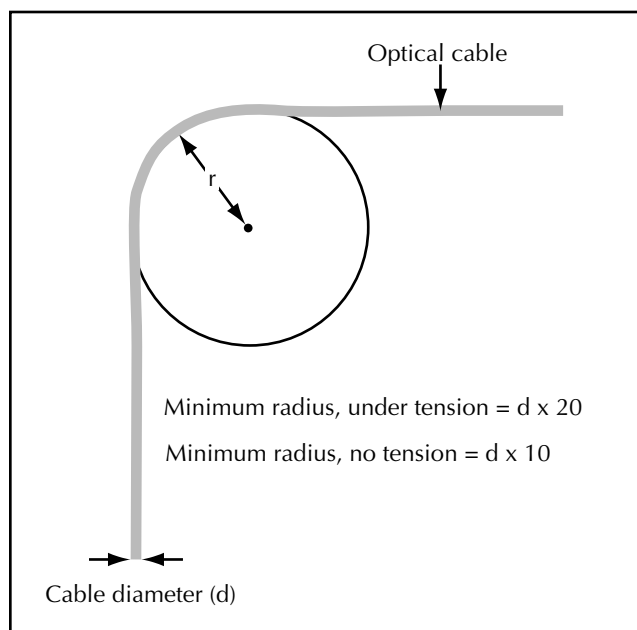


Figure 8: Fiber optic cable bending radius.

i) When pulls are accomplished in two or more stages, and spare cable must be unreeled, it shall be configured in large figure-eights on a safe, clean, flat surface.

j) When pulling fiber optic cable through nonmetallic raceways, or nonmetallic 90-degree elbows with rope, maximum speed through a duct shall be about 3 feet (910 mm) per second. If mule tape is used, the top speed shall be 9 feet (2.74 m) per second. The intent of this requirement is that the nonmetallic conduit or elbows will not be cut or grooved by the pulling process.

k) When underground raceways containing optical cables enter a structure, the raceway shall be sealed to prevent the entry of gasses into the structure. The entry of outside plant cables into a structure may require special fire safety consideration.

4.7 Cable Bending Radii

Unless stated otherwise by the cable manufacturer, the minimum bending radius for optical cables shall be ten times the cable diameter for cables that are not under tension (as when laid in a cable tray), and twenty times cable diameter when under tension (as when being pulled into place). Figure 8 illustrates the fiber optic cable bending radius.

4.8 Cables Installed in Cable Trays

Optical fiber cables in trays shall be carefully placed without tugging on the outer jacket of the cable. Cables shall be placed where they cannot be crushed. Optical cables shall be separated from electrical power cables by installing them in a separate and clearly marked interduct.

4.9 Cables Installed Vertically

Fiber optic cables installed in any type of vertical cable tray, raceway, or shaft shall be clamped at the top of the run, and at frequent intervals, so that the entire weight of the cable is not supported at the top. The weight of the cable shall be evenly supported over its entire length.

Vertical clamping intervals may vary from 3 feet (910 mm) for outdoor installations with wind stress prob-

lems, to as much as 50 feet (15.2m) for indoor installations. At no time shall supports be placed further apart than the cable's rated vertical rise.

Several loops of cable, at least 20 times cable diameter, shall be provided at the top and bottom of any vertical runs longer than 100 feet. Intermediate loops may be provided if desired.

4.10 Directly Buried Optical Cables

Only armored or other heavy-duty cables shall be directly buried. Steel conduit, metal braids, or substantial armor shall be used where cables may be subject to rodents or gophers.

Directly buried cables are frequently exposed to ground water. Such cables shall be water blocked in the core and within the primary sheath to avoid water migration along the cable. A number of methods may be used.

Optical cables shall be buried below the frost line for the geographic area in which they are installed; exceptions may be used for locations where permafrost exists.

When cables are plowed into place, only cables design for the purpose shall be used.

Where freezing water presents a threat, cables shall be completely filled to prevent the entrance or migration of water.

4.11 Aerial Cables

To account for thermal expansion and contraction, all outdoor aerial cables shall be installed as required by the National Electrical Safety Code. They shall be supported by a messenger wire as required by the National Electrical Safety Code and Article 321 of the National Electrical Code.

Unless designed for such use by the manufacturer, aerial cables shall be round, loose tube, outside plant cables.

Aerial fiber optic cables shall have temperature ranges (specified by the manufacturer) that correspond to the environment in which they will be installed. Cables for long outdoor aerial runs shall be temperature stabilized.

5. Cable Splices and Terminations

All optical splices and terminations shall be made mechanically strong, and optically sound (that is, having low loss). Figure 9 shows one common type of fiber optic cable splice.

All optical cable splicing and terminations, including all cable preparation, shall be performed with tools designed for the purpose. Standard electrician's strippers and tools shall not be used.

Alcohol used for cleaning fibers during the splicing and termination process shall be 95 percent pure, with no additives.

Compressed air used in the splicing and termination process shall be lens grade (also called optical grade).

5.1 Splices

Unless specifically designed for the purpose, mechanical optical splicing devices shall be used once only. They shall not be reused.

Optical splicing techniques that involve the use of high temperatures or electric arc (such as fusion splicing) shall not be performed in environments

that may be explosive, such in as manholes, unless they are first ventilated and a gas check is performed.

5.2 Terminations

Optical connectors shall meet the attenuation specified by the manufacturer. Where repetitive connecting and disconnecting will be necessary keyed connectors shall be used, as tested by standard OTDR or power meter test sets.

All field-polished optical fibers shall be inspected with a microscope designed for the purpose. The end surface of the fibers core shall be free of cracks and defects. It shall be permissible for the cladding of the fiber end to contain cracks or defect, so long as these defects do not extend into the core.

Alcohol used for cleaning fibers during the termination process shall be 95 percent pure, with no additives.

Compressed air used in the termination process shall be lens grade (also called optical grade).

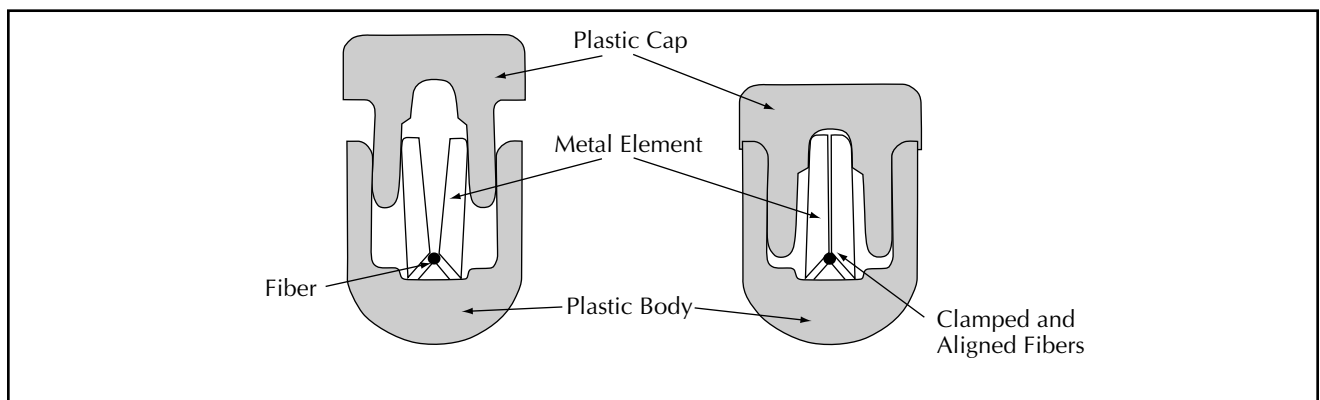


Figure 9: One common type of mechanical optical fiber splice.

Terminating Singlemode Fibers

Singlemode fibers shall not be field-terminated in connectors, except when the work is performed by technicians who are experienced in such connectorization, using materials designed for the purpose. Otherwise, singlemode terminations shall be made by splicing factory-made terminations onto the open end of an optical fiber by obtaining factory-made pigtails, cutting them in half, and splicing each of the cut ends of the pigtail onto the fibers to be terminated.

5.3 Safety Precautions for Splicing and Terminating Fiber Optic Cables

Live optical fiber ends (*live* fibers are those with signals being sent through them) shall not be inspected by technicians; fibers shall be *dark* (no signal being transmitted) when inspected. Care shall be taken in verifying that the fibers are not live, because the light used in the majority of optical systems is not visible to the human eye.

If there is a risk of fibers being inspected live, especially when the system light source is a laser, all technicians working on the system shall wear protective glasses that have infrared filtering.

Fiber optic work areas shall be clean, organized, well-lit, and shall be equipped with a bottle or other suitable container for broken or stray fiber pieces.

No food, drink, or smoking shall be allowed in areas where fiber optic cables are spliced or terminated, or in any area where bare fibers are being handled.

Technicians making fiber terminations or splices or working with bare fiber shall be supplied with double-sided tape, or some other effective means for picking up broken or stray pieces of fiber. All work areas where bare fiber may exist shall be repeatedly and consistently cleared of all bare fiber pieces. All bare fiber pieces shall be disposed of so that they cannot escape and cause a hazard. For example, bare fibers should be sealed in some type of bottle or container before being dumped into a wastebasket.

All technicians working on bare fiber shall thoroughly wash their hands immediately when leaving the work area. They shall also check their clothing, and pat themselves with clean tape to remove any stray pieces of bare fiber.

6. Fiber Optic Hardware

All hardware used with optical fibers and cables shall be specifically designed for this purpose. Optical hardware shall provide sufficient bending room, proper support, and adequate physical protection for all cables and fibers installed in it. Standard electrical outlet boxes and the like shall not be used with fiber optic cables.

In general, optical hardware shall be equipped with cable terminating equipment such as ground clamps, (where necessary) provisions for securing the cable and strength member, and shall have a means of organizing and storing unjacketed fibers. Optical hardware shall be over-sized to accommodate future expansion.

Optical hardware shall be placed in close proximity to, or in the same location as, the equipment it will be connected with, such as data centers or public branch exchanges (PBXs).

Breakout kits and furcation tubing shall be used whenever necessary to protect uncabled fibers. Such uncabled fibers (typically emerging from loose-tube cables) are vulnerable to damage, and shall not be run unprotected.

6.1 Wall Outlets

Optical wall outlets shall be permanently and securely mounted, and shall be placed in areas where neither they nor the cables that attach to them are likely to be damaged. In structured cabling systems with horizontal fiber optic cable runs to telecommunication outlets, standard electrical boxes may be used with special brackets or wall plates that are designed to accommodate optical fiber cable adapters or connectors.

When fiber optic cables are run exposed to a wall outlet, rather than in a raceway, they shall be supported by clamps or straps to a permanent framing

member or a permanent building surface within 12 inches (305mm) of the outlet. (See Figure 10). Cables fished into place are excepted from this requirement.

The entry of an optical cable into a wall outlet shall not exceed the cable's minimum bending radius requirements.

6.2 Patch Panels

Patch panels and similar equipment shall be equipped with locking devices, unless the hardware is located in an area that is accessible only to qualified personnel.

Connectors that mate in patch panels or similar pieces of hardware shall be held substantially in contact with each other.

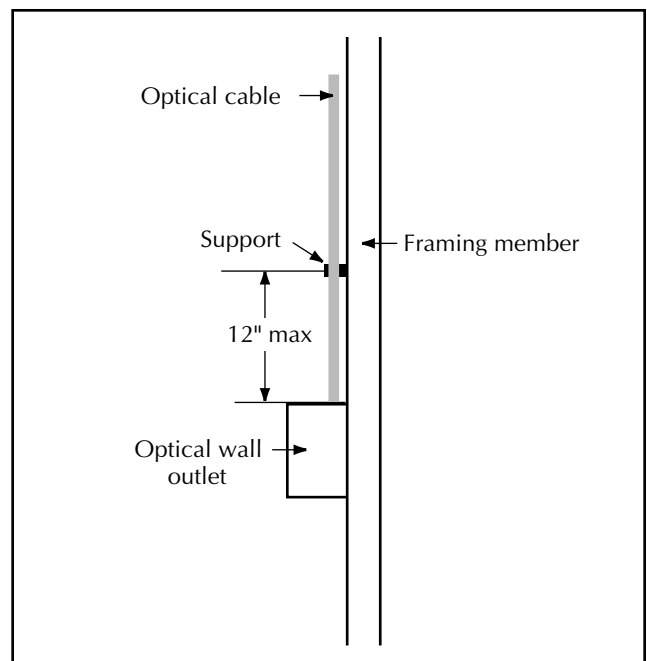


Figure 10: Support for fiber optic cable running exposed to a wall outlet.

7. Testing

Fiber optic testing requires instruments that have been designed specifically for the purpose. All optical test equipment shall be matched to the system being tested.

Test sources and power meters are used for system loss measurements. The most common tester is the optical power meter, because optical power value (loss) is the measurement most commonly required.

Specialized instruments are used to find faults in cables, and for troubleshooting. Typically, visual fault locators are used for short cables and optical time domain reflectometers (commonly called OTDRs) for long cables. OTDRs are especially effective for precisely locating faults in cables, and are very frequently used for testing optical return loss in singlemode systems.

Testing shall be performed according to the following standards:

- TIA/EIA 526-7, *Measurement of Installed Singlemode Cable Plant*
- TIA/EIA 526-14 (Rev. A), *Measurement of Installed Multimode Cable Plant*
- Annex H of EIA/TIA 568-A, *Commercial Building Telecommunications Wiring Standards*

7.1 Required Tests

The following tests shall be performed on all fiber optic cable installations:

- a) Continuity testing upon delivery of optical cables to the site of the installation.
- b) End-to-end loss testing for each complete transmitter-to-receiver link.

- c) End-to-end testing on each individual link in the system, if transmitter-to-receiver loss is beyond acceptable limits.

In addition, other types of testing may be required for certain types of installations.

7.2 Tests Not Performed in the Field

Tests for modal dispersion and chromatic dispersion are not normally performed on a job site. However, specific calculations to estimate both modal and chromatic dispersion shall be made when designing optical links.

Fiber geometry tests shall not be performed in the field, except in special circumstances.

Fiber bandwidth tests shall not be performed in the field, except in special circumstances.

7.3 Loss Testing

All loss testing shall be performed by trained personnel, using equipment designed for the purpose, according to industry standard test procedures.

Loss testing, with the exception of very long outdoor runs, shall not be performed solely with an ODTR. If OTDR testing is performed an optical power meter shall also be used for loss testing (except for very long runs).

Long runs shall be tested with an optical time domain reflectometer, and permanent copies shall be made of all OTDR traces. All such trace copies shall be clearly marked with the data taken, and details of the cable and fiber runs.

Launch cables, pigtails, or similar cables used with optical testers shall be regularly tested and cleaned to

assure their quality. Poorly performing cables shall be discarded.

7.4 OTDR Testing

All optical time domain reflectometer (OTDR) testing shall be performed by trained personnel, using certified equipment designed for the purpose. The technicians performing the tests shall be trained not only in operation of the OTDR equipment, but also in the interpretation of OTDR traces. A sample OTDR trace is shown in figure 11.

Loss testing shall not be performed with OTDRs only.

When OTDRs are used to test for optical return loss, they shall be equipped with long launch cables and each fiber shall be tested from both ends.

7.5 Documentation Of Test Results

All optical test results shall be thoroughly and accurately documented, and copies of the test results saved in a permanent form, typically both as hard-copy and on computer disk.

In general, documentation of test results shall include the following information:

- a) Cable type and length.
- b) Fiber type and size.
- c) Splice and termination points.
- d) Connector types.
- e) Splice types.
- f) Cable paths.
- g) End-to-end losses of completed transmitter-to-receiver links.
- h) (Optional) End-to-end losses of individual fiber links.

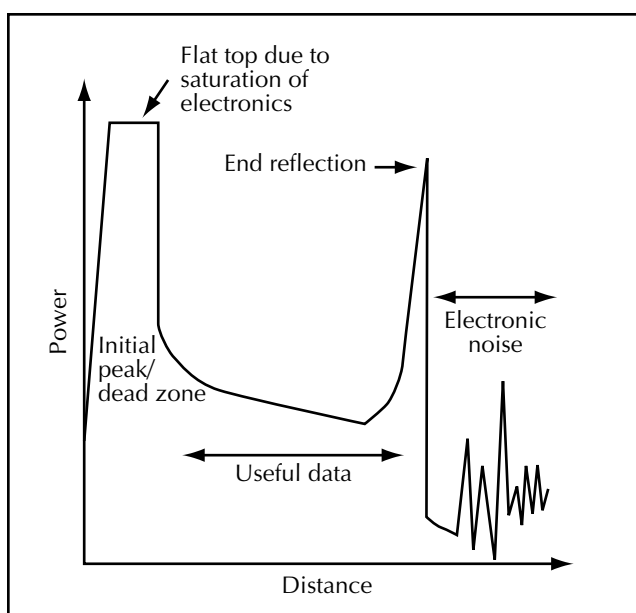


Figure 11: Sample OTDR trace.

(This annex is not a part of the standard)

Annex A: Reference Standards

ANSI/NFPA 70-1996, *National Electrical Code*

National Fire Protection Association
1 Batterymarch Park
P.O. Box 9101
Quincy, MA 02269-9101
(800) 344-3555
www.nfpa.org

ANSI/IEEE C2-1997, *National Electrical Safety Code*

Institute of Electrical and Electronics Engineers
445 Hoes Lane
P.O. Box 1331
Piscataway, NJ 08855-1331
(800) 678-4333
www.ieee.org

EIA/TIA 526 Series, *Optical Fiber Systems Test Procedures*

ANSI/EIA/TIA 568-A-1995, *Commercial Building Telecommunications Cabling Standard*

ANSI/EIA/TIA 569-1990, *Commercial Building Standard for Telecommunications Pathways and Spaces*

ANSI/EIA/TIA 590-A-1996, *Standard for Physical Location and Protection of Below-Ground Fiber Optic Cable Plant*

ANSI/EIA/TIA 606-1993, *Administration Standard for the Telecommunications Infrastructure of Commercial Buildings*

ANSI/EIA/TIA 607-1994, *Commercial Building Grounding and Bonding Requirements for Telecommunications*

Electronic Industries Association
Telecommunications Industry Association
2500 Wilson Blvd.
Arlington, VA 22201
(703) 907-7700
www.tiaonline.org

Order EIA/TIA standards from:

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15 Inverness Way East
Englewood, CO 80112
(800) 854-7179

Other *National Electrical Installation Standards* published by NECA:

National Electrical Contractors Association
3 Bethesda Metro Center, Suite 1100
Bethesda, MD 20814
(301) 215-4504 tel
(301) 215-4500 fax
www.neca-neis.org

NECA 1-2000, *Standard Practices for Good Workmanship in Electrical Contracting*

NECA 100-1999, *Symbols for Electrical Construction Drawings* (ANSI)

NECA 101-2001, *Standard for Installing Steel Conduit (Rigid, IMC, EMT)*

NECA/AA 104-2000, *Recommended Practice for Installing Aluminum Building Wire and Cable* (ANSI)

NECA 400-1998, *Recommended Practice for Installing and Maintaining Switchboards* (ANSI)

NECA 402-2000, *Recommended Practice for Installing and Maintaining Motor Control Centers*

NECA/EGSA 404-2000, *Recommended Practice for Installing Generator Sets* (ANSI)

NECA/IESNA 500-1998, *Recommended Practice for Installing Indoor Commercial Lighting Systems* (ANSI)

NECA/IESNA 501-2000, *Recommended Practice for Installing Exterior Lighting Systems* (ANSI)

NECA/IESNA 502-1999, *Recommended Practice for Installing Industrial Lighting Systems* (ANSI)

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Standards & Safety
Index: NECA 301
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