

The Fiber Optic Association, Inc.

1119 S. Mission Road #355, Fallbrook, CA 92028

1-760-451-3655 Fax 1-781-207-2421

Email: info@thefoa.org <http://www.TheFOA.org>

FOA Reference Guide To Outside Plant Fiber Optics Textbook Guide For Instructors With Chapter Quiz Answers

The Fiber Optic Association, Inc., the nonprofit professional society of fiber optics, has become one of the principal sources of technical information, training curriculum and certifications for the fiber optic industry. The FOA created its Online Reference Guide (www.foaguide.org) to provide a more up-to-date and unbiased reference for those seeking information on fiber optic technology, components, applications and installation. It's success confirms the assumption that most users prefer the Internet for technical information.

With this book, we address the needs for those who prefer printed books or who must have them to meet academic requirements. For those who want this printed version but also want access to the web for color graphics, automatic self-testing quizzes or links to even more technical information, we have provided links on the FOA Online Reference Guide (ORG) website to the appropriate sections covered in this book.

Guide to The FOA Reference Guide to Outside Plant Fiber Optics and The FOA Online Reference Guide to Fiber Optics

The FOA Reference Guide to Outside Plant Fiber Optics and The FOA Online Reference Guide to Fiber Optics, OSP Section were created for training designers and installers of fiber optic networks. It only includes a short introduction to the basics of fiber optics as needed to understand operational issues, leaving the physics and mathematics of fiber optic technology to the high level textbooks. Instead it focuses on the practical aspects of designing, installing, testing and troubleshooting fiber optic cable plants and networks.

This reference has been edited by a number of experienced professionals and instructors in fiber optics, all of whom are involved in teaching fiber optics courses regularly. The material comes from their practical experience and the assistance of a number of vendors who provided the latest product information. Those instructors have joined together to produce this website.

The organization of the book and website follows the typical training programs given by most instructors. It starts with a section on the basics of fiber optic technology (Fiber Optics, The Basics), which includes topics covering the jargon and the technology of fiber optics, how fiber is used in networks including new material on fiber optic transmission systems, components, installation and testing, to give the reader a complete, concise view of the technology. It is then divided into additional sections that cover all the relevant process topics in much greater detail and the website includes "Virtual Hands-On" tutorials on common processes used in fiber optics.

The timeliness of the material is important in a technology like fiber optics that is moving rapidly. New product innovation and rapid cost reduction are the norm for fiber optics. We have tried to include the latest material and intend to update the material regularly, a major advantage of modern publishing techniques and web-based reference materials.

Note: The materials included in the textbook are similar to another FOA textbook *The FOA Reference Guide to Fiber Optics*, from which it was developed by adding additional materials relating to OSP fiber networks.

Chapter Guide for The FOA Reference Guide to Outside Plant Fiber Optics

Chapter numbers refer to the Textbook

ORG/OSP = FOA Online Reference Guide To Fiber Optics

(<http://www.thefoa.org/tech/ref/OSP/>)

Chapter 1, Introduction to Fiber Optics

ORG, Basic Overview

This is an introduction to fiber optics, including some history, and an overview of where it is used. A short section discusses the differences between fiber and copper and what has become the basis for fiber's dominance of the communications industry. Finally, to emphasize their importance, safety and the need for cleanliness are discussed.

Chapter 2, Jargon

ORG/OSP, Fiber Optic Jargon

The first thing one needs to understand in order to be able to comprehend a new technology is the "language" unique to that technology. This section gives concise, often illustrated, definitions of the terms used in fiber optics. It is a very important section, as a basic understanding of the terms used will make the rest of the material much easier to comprehend.

Chapter 3, Fiber Optic Communications

ORG/OSP, Basic Applications and Transmission Systems

In this chapter, outside plant network applications for telecom, CATV and other networks are described. Fiber's role in each of the networks is covered in detail, in relation to the copper wiring and wireless networks. It is important to understand how each of these types of networks use fiber and how they differ.

Supplemental reading: ORG, Applications

Chapter 4, Fiber Optic Transmission Systems And Components

ORG/OSP, Applications, Communications, Fiber Optic Datalinks, Fiber Optic Transceivers for Datalinks

This chapter covers how fiber optic data links work to transmit digital and analog signals over optical fibers. It describes the design of transceivers (transmitter and receiver in one module) and the types of sources and detectors used for various systems. DWDM

and CWDM wavelength division multiplexing are explained in this chapter and an introduction is given on link loss budgets.

Chapter 5, Optical Fiber ORG/OSP, Optical Fiber

This chapter covers the heart of fiber optic technology, the fiber itself. Here you learn how fiber works, the different types of fiber and important fiber specifications. Special fiber characteristics related to long distance OSP links are explained. Like the Jargon section, this section provides important background information for many of the other sections.

Supplemental reading: ORG, Fiber Optic Components, Optical Fiber

Chapter 6, Fiber Optic Cable ORG/OSP, Fiber Optic Cable

This chapter is an overview of the purpose of cables (basically protecting fibers in the outside world) and how they are used. It covers the different types of cables and their usage in underground, direct buried, aerial and submarine/underwater applications. Choosing cable types appropriate for the application is very important for designers of networks, as it affects network cost and reliability, but requires knowing the different types available and their properties that determine the correct choice. Be sure to note the sections near the end on indoor cable flammability ratings and color codes.

Supplemental reading: ORG, Fiber Optic Components, Cable. View VHO: Cable Preparation

Chapter 7, Splices and Connectors ORG/OSP, Splices and Connectors

This is an overview of termination and splicing types and techniques. The student should physically examine samples of the most popular splices (fusion and mechanical) and connectors (ST, SC, LC) if possible but the page includes photos of most types.

The discussion of splicing covers technical details of fusion and mechanical splicing, with emphasis that most SM outside plant splicing is fusion, while mechanical splices are used more for restoration and MM splicing. Students should understand which connectors are used where, the various methods of termination and ferrule end polishes, as they are important issues in choosing and using connectors.

Supplemental reading: ORG, Fiber Optic Components, Termination and Splicing. View VHO: all three splicing and at least one of the adhesive/polish connector tutorials, the PPS termination, and SM termination.

Chapter 8, Testing ORG/OSP, Testing

This chapter contains a lot of material. The types of test equipment are important to understand, as are the relevant specifications and applications for the instruments.

Three types of testing are included: continuity testing, insertion loss tested by a light source and power meter and OTDR testing according to industry standard test procedures. Testing chromatic dispersion, polarization mode dispersion and spectral attenuation for long distance and DWDM networks are included. This section includes the basics of testing but supplemental tutorials cover actual processes.

Supplemental reading: OSP: Testing & Troubleshooting Fiber Optic Systems. Read “Fiber Optic Test Instruments and the VHO on “Insertion Loss Testing” and “Using an OTDR.”

Chapter 9, Fiber Optic Network Design

ORG/OSP, Network Design

This chapter covers only an overview of outside plant fiber optic network design; essentially enough for the reader to understand the process behind network design. Since the FOA has a certification on Fiber Optic Network Design, there is a large amount of reference material on this reference site that is appropriate for advanced study.

Supplemental reading: Designing Fiber Optic Networks

Chapter 10, Fiber Optic Network Installation

ORG/OSP, Installation

The topic of fiber optic cable plant installation is a very diverse subject, since fiber is used in so many different types of OSP installations in so many different environments. This section provides an overview of the installation processes for many applications, with an emphasis on safety.

Supplemental reading: ORG: Installation of FO Cable Plants. Read topics of interest to you plus “Safety Procedures” and “Cleaning Fiber Optic Connections.”

Appendix B, Fiber To The Home

ORG: FTTH

Fiber to the home/curb/business/premises are all terms used for directly connecting the subscriber with fiber. As one of the most active areas of OSP fiber optics, a special section is provided for covering this technology. Depending on the course, it may be used as a supplement to Chapter 4.

Appendix D, Definitions of Terms

ORG/OSP, Definitions of Terms

This section is provided for reference purposes and as an elaboration to the Jargon section.

Additional Reference Materials On *The FOA Online Reference Guide*

While the book and ORG/OSP website cover the information covered in courses and for the CFospT exam, there is additional material online in the ORG that provides greater details on many relevant subjects. Here is a summary of the topics covered.

This section is a “work in process” where we will be updating and adding additional information regularly. Some topics are included without links while work continues on those topics.

Standards

An overview of the standards process and standards for fiber optic components and testing. Most standards are written for manufacturers who interpret them for their customers, but a basic understanding of the goals of standards is important for everyone involved in fiber optic technology.

Applications of Fiber Optics

While the major emphasis of The FOA is communications applications of fiber optics, we have an interest in other applications like sensors, lighting and inspection. This section includes articles on all these various applications.

Fiber Optic Technology and Standards

This section includes additional technical topics of general interest and references to fiber optic standards.

Fiber Optic Components

This is one of the most important topics for study and this section not only elaborates on component types and specifications, but includes many slide-show tutorials and what we call “Virtual Hands-On” tutorials covering fiber optic processes like cable preparation, termination and splicing, in step-by-step format. These “Virtual Hands-On” tutorials have been created from studies of the process that analyzes them in detail, breaks them into individual steps and explains those steps including background information and options. These “Virtual Hands-On” tutorials are generally considered better than videos as they are easier to understand and each step can be studied as long as desired. Links to videos are also included for those who prefer online video.

Designing Fiber Optic Networks

Since the FOA has a certification on Fiber Optic Network Design, there is a large amount of reference material here and on the FOA Tech Topics site that is appropriate for advanced study. Those interested in the topic or the FOA CFOS/D certification should study this section carefully.

Installation of FO Cable Plants

This is one of the most important topics for fiber optic technicians involved in field installation. It covers topics that primarily elaborate on the Basic coverage of installation

and explain exactly how some common elements of installation like attaching pulling eyes or “figure-8-ing” cable are done.

Testing & Troubleshooting Fiber Optic Systems

The proof of the quality of any fiber optic installation or manufacturing process is the test results. In this section, we have provided much more information than is commonly available on fiber optic testing, covering the instruments, the tests broken down into specifics for various components or subsystems, and several explanations of technical issues often glossed over that can greatly affect measurement validity.

Using Fiber Optic Systems

While our primary focus has been on installation, understanding how to use the systems, from managing design and installation through maintenance and restoration, is a major issue for owners of the systems and their contractors.

Tech Topics

The FOA “Tech Topics” covers other materials relating to fiber optics. It is linked off the FOA home page.

Future Reference Usage

Studying the sections referenced above, reading supplemental materials relevant to your interests and work and correctly answering the section quizzes will prepare you for the CFospT exam. The FOA will always be updating this website to include new technology, applications and products in the future. Feel free to use it as a refresher course at any time or access it from the field when you need a quick reference on a process or procedure or just to help educate others (such as contractors discussing procedures or standards with their customers.) If you have a web-enabled device like a smart phone or iPad, most of the site has been designed to be viewable from one those devices.

We also recommend you sign up for the FOA email lists where we send out monthly news on fiber optics.

Questions and Answers to Chapter Quizzes

Chapter 1 Quiz-Introduction to Fiber Optics

True/False

Indicate whether the statement is true or false.

- _____ 1. Most outside plant installations are singlemode fiber.
- _____ 2. Splicing is very rare in premises networks.
- _____ 3. Fiber is used in long distance phone networks because it is much cheaper than copper wire.
- _____ 4. Dangerous light from fiber optic cables is bright and easily visible.
- _____ 5. Besides causing attenuation, dirt particles can cause scratches on the polished fiber ends.

Multiple Choice

Identify the choice that best completes the statement or answers the question.

- _____ 6. 1. Outside plant cabling can be installed by _____.
A. Pulling in underground in conduit
B. Direct burial
C. Aerial suspension
D. All of the above
- _____ 7. 2. Underground cable generally includes a gel, powder or tape for protection from _____.
A. Pulling friction
B. Lightning strikes
C. Moisture
D. Fiber abrasion
- _____ 8. 3. Armored cable is used in outside plant installations to _____.
A. Prevent rodent damage
B. Protect from dig-up damage
C. Increase pulling tension
D. Conduct lightning strikes
- _____ 9. Concatenation or the joining of two cables in a long outside plant run is almost always done by _____.
A. Mechanical splicing
B. Fusion splicing

- C. Field installation of connectors
- D. Splicing on pigtailed connectors

- _____ 10. Premise cables in LAN backbones often contain _____.
- A. Only multimode fiber
 - B. Only singlemode fiber
 - C. Both multimode and singlemode fiber
 - D. Plastic optical fiber
- _____ 11. Premises cables must be rated for _____ to meet codes.
- A. Pull strength
 - B. Bend radius
 - C. Weight in cable trays
 - D. Fire retardance
- _____ 12. The protective gear every VDV installer must always wear is _____.
- A. Eye protection
 - B. Plastic apron
 - C. Gloves
 - D. Shoe covers
- _____ 13. Information on the safety of chemicals used in fiber optics are _____.
- A. Available from National Institutes of Health
 - B. In MSDS sheets supplied by manufacturers
 - C. Required to be in every installer's tool kit
 - D. Rarely useful
- _____ 14. Always keep _____ on connectors when not connected to equipment or being tested.
- A. Mating adapters
 - B. Strain relief boots
 - C. Sticky tape
 - D. Dust caps

Chapter 1
Answer Section

TRUE/FALSE

1. ANS: T
Since most OSP installs are longer links, SM is the fiber of choice. Some utilities and municipal networks can use MM fiber, but it's less common.
2. ANS: T
Most premises cables are simple single cable runs, terminated on each end.
3. ANS: T
The greater bandwidth and lower attenuation of fiber allows it to carry more signals further without regeneration, making it considerably less expensive.
4. ANS: F
Most fiber systems and test equipment use infrared light which is invisible to the human eye.
5. ANS: T
Most airborne dirt is hard enough to scratch the ends of fibers in physical-contact connectors.

MULTIPLE CHOICE

6. ANS: D
All these types of installations are possible in the OSP.
7. ANS: C
Moisture is a problem in all OSP cables.
8. ANS: A
Armoring can stop rodents from harming cables.
9. ANS: B
Fusion splicing is the most reliable method of joining cables.
10. ANS: C
Backbones often use both fiber types - MM to carry today's traffic and SM for future expansion.
11. ANS: D
Any cable installed indoors must be rated for fire retardance to meet electrical and building codes.
12. ANS: A
The biggest danger in fiber installs is getting fiber scraps in your eyes.
13. ANS: B
You should consult Material Safety Data Sheets for all chemicals (solvents, cleaners, adhesives, etc.) used in fiber installations.
14. ANS: D
Dust caps protect the ends of the connector ferrules from damage and protect them from contamination.

Chapter 2 Quiz-Jargon

True/False

Indicate whether the statement is true or false.

- _____ 1. Optical fibers can transmit either voice, data or video and either analog or digital signals.
- _____ 2. Singlemode fiber has a smaller core than multimode fiber.

Multiple Choice

Identify the choice that best completes the statement or answers the question.

- _____ 3. In an optical fiber, the light is transmitted through the _____.
- A. Core
 - B. Cladding
 - C. Buffer
 - D. Jacket
- _____ 4. The diameter of an optical fiber is traditionally measured in _____.
- A. Meters
 - B. Millimeters
 - C. Microns (micrometers)
 - D. Nanometers
- _____ 5. Rays of light transmitted in multimode fiber are called _____.
- A. Reflections
 - B. Refractions
 - C. Waves
 - D. Modes
- _____ 6. Loss of a fiber or any fiber in a cable is measured in _____.
- A. dB
 - B. dBm
 - C. milliwatts
- _____ 7. 10 dB corresponds to a factor of _____ in power.
- A. 2
 - B. 10
 - C. 20
 - D. 100
- _____ 8. A fiber stripper removes the _____ of the fiber.
- A. Core
 - B. Cladding
 - C. Buffer coating

- _____ 9. The ____ protects the fiber from harm.
- A. Primary buffer coating
 - B. Aramid fiber strength members
 - C. Jacket
 - D. All of the above
- _____ 10. Which fiber optic test instrument uses backscattered light for measurements?
- A. OLTS
 - B. OTDR
 - C. VFL
 - D. Tracer
- _____ 11. The wavelength of light used for most fiber optic systems is in the _____ region and _____ to the human eye.
- A. ultraviolet, invisible
 - B. solar, visible
 - C. infrared,, invisible

Chapter 2 Quiz-Jargon
Answer Section

TRUE/FALSE

1. ANS: T
Telecom or LAN signals are digital, but most CATV and CCTV signals are analog.
2. ANS: T
The core of a singlemode fiber is 8-9 microns in diameter, while multimode fiber cores are 50 or 62.5 microns.

MULTIPLE CHOICE

3. ANS: A
Light travels in the core, where it is trapped by the cladding. The buffer is a plastic protective coating for the fiber and the jacket is the outside layer of a cable.
4. ANS: C
Multimode fiber, for example, is either 50 or 62.5 micron core diameter and 125 micron cladding diameter.
5. ANS: D
Multimode fibers have many modes or rays of light, while singlemode fiber only carries one mode.
6. ANS: A
dB is a relative measurement used for loss. dBm is absolute power referenced to 1 milliwatt.
7. ANS: B
dB is a logarithmic function, $dB = 10 \log(\text{power ratio})$, so 10 dB = 10X, 3 dB = 2X, etc.
8. ANS: C
Stripping the fiber removes the plastic buffer coating so a connector can be attached to the glass or the fiber can be spliced.
9. ANS: D
The primary buffer coating on the fiber is the first layer of protection, the jacket is the outer layer and the aramid fiber strength members allow pulling the fiber optic cable without damaging the fibers.
10. ANS: B
The OLTS makes a direct measurement, operating like a datalink. The OTDR uses backscattered light to indirectly measure fiber loss, length and find faults.
11. ANS: C
Most fiber optic systems use infrared light as it has lower loss due to scattering in the fiber.

Chapter 3 Quiz - Fiber Optic Communications

True/False

Indicate whether the statement is true or false.

- _____ 1. The biggest advantage of optical fiber is the fact it is the most cost effective means of transporting information.
- _____ 2. Telephone networks have been converted to fiber, including long distance and metropolitan networks, but fiber to the home (FTTH) is not yet feasible.

Multiple Choice

Identify the choice that best completes the statement or answers the question.

- _____ 3. Today, with the exception of some _____, the entire telephone backbone is fiber optics.
A. Rugged or remote locations
B. Ultra-high speed connections
C. Ultra-high speed connections
D. Triple play systems
- _____ 4. _____ companies “overbuild with fiber, often lashing fiber optic cables to installed aerial coax cable.”
A. Independent telephone
B. CATV
C. Utilities
D. Private network
- _____ 5. Copper networks can be converted to fiber optics easily using:
A. Fiber hubs
B. Media converters
C. Patch panels
D. Rewiring

Multiple Response

Identify one or more choices that best complete the statement or answer the question.

- _____ 6. The bandwidth and distance capability of optical fiber means that _____ (choose all that apply)
A. Fewer cables are needed
B. Fewer repeaters are needed

- C. Less power is consumed by the network
- D. Less maintenance is required

_____ 7. Which of the following typically use fiber optic backbones? (choose all that apply)

- A. Telephones
- B. CATV
- C. Internet
- D. Cell Phones

Chapter 3 Quiz
Answer Section

TRUE/FALSE

1. ANS: T
Fiber can transport more information longer distances in less time than any other communications medium,
2. ANS: F
FTTH is cost effective today because of the demand for high speed digital services in the home and the development of lower cost PON networks.

MULTIPLE CHOICE

3. ANS: A
Some rural or remote locations around the world use satellites instead of fiber to reach distant users.
4. ANS: B
CATV companies convert their RF signals to fiber using analog transmission and overbuild coax cables with lightweight fiber cables lashed to the coax or messenger cables.
5. ANS: B
Media converters convert copper to fiber or even multimode to singlemode fiber.

MULTIPLE RESPONSE

6. ANS: A, B, C, D
All these answers are advantages of using optical fiber.
7. ANS: A, B, C, D
Fiber is used for backbones for all these networks, including cell phones for its bandwidth/distance advantage making it lower cost.

Chapter 4 Quiz - Fiber Optic Transmission Systems And Components

True/False

Indicate whether the statement is true or false.

- _____ 1. Fiber optic links generally use two fibers for full duplex (bidirectional) links.
- _____ 2. LEDs have higher output power and bandwidth than lasers.

Multiple Choice

Identify the choice that best completes the statement or answers the question.

- _____ 3. Singlemode fiber systems covering long distances and using DWDM use _____ sources.
A. F-P laser
B. DFB laser
C. VCSEL
D. LED
- _____ 4. Wavelength division multiplexing uses _____ to transmit multiple signals on a single fiber.
A. The ability of fiber to transmit multiple wavelengths without mixing
B. F-P Lasers
C. The wide spectral width of lasers
D. The high fiber bandwidth
- _____ 5. CWDM systems require _____ to allow transmitting in the E-Band (1260-1360 nm).
A. Low water peak fiber
B. DFB lasers
C. 1490 nm pump lasers
- _____ 6. Long wavelength singlemode links at wavelengths in the range of 1300-1650 nm links must use _____ detectors in the receiver for the best sensitivity performance.
A. Silicon
B. Germanium
C. InGaAs
- _____ 7. Fiber amplifiers and DWDM work in the _____ wavelength range.
A. 650-850
B. 850-1300
C. 1300-1550
D. 1480-1650

Multiple Response

Identify one or more choices that best complete the statement or answer the question.

_____ 8. Singlemode transceivers use _____ sources for their higher coupled power and bandwidth.

- A. LED
- B. VCSEL
- C. F-P lasers
- D. DFB lasers

_____ 9. Multimode transceivers use _____ sources depending on their requirements for coupled power and bandwidth.

- A. LED
- B. VCSEL
- C. F-P lasers
- D. DFB lasers

Chapter 4 Quiz
Answer Section

TRUE/FALSE

1. ANS: T
Most systems operate by transmitting in one direction on one fiber and in the reverse direction on another fiber for full duplex operation. It's possible to transmit both directions on one fiber but it requires couplers to do so and fiber is less expensive than couplers.
2. ANS: F
LEDs have much lower power outputs than lasers. LEDs have much less bandwidth than lasers and are limited to systems operating up to about 250 MHz or around 200 Mb/s.

MULTIPLE CHOICE

3. ANS: B
DFB lasers have higher power, narrower spectral width and are capable of faster modulation so they are used in the longest links.
4. ANS: A
The ability of fiber to transmit multiple wavelengths without mixing allows a fiber to transmit multiple signals on separate wavelengths.
5. ANS: A
Low water peak fiber is necessary to allow CDWD to use the wavelengths where normal fibers have high attenuation from water peak absorption.
6. ANS: C
Long wavelength systems usually use InGaAs (indium gallium arsenide) detectors as they have lower noise than germanium which allows for more sensitive receivers.
7. ANS: D
In telephony, fiber amplifiers combine with [DWDM](#) (dense wavelength division multiplexers) to overcome the inefficiencies of DWDM couplers for long haul transmission.
The typical fiber amplifier works in the 1480-1650 nm band.

MULTIPLE RESPONSE

8. ANS: C, D
See table: Typical Fiber Optic Source Specifications
9. ANS: A, B, C
See table: Typical Fiber Optic Source Specifications

Chapter 5 Quiz – Optical Fiber

Multiple Choice

Identify the choice that best completes the statement or answers the question.

- _____ 1. Singlemode fiber has a _____ light-carrying core than multimode fiber.
A. Smaller
B. Larger
C. Same size
- _____ 2. What is the core size of singlemode fiber?
A. 5 mm
B. 9 microns
C. 50 microns
D. 63.5 microns
- _____ 3. Singlemode fiber has _____ bandwidth than multimode fiber.
A. More
B. Less
C. The same
- _____ 4. What wavelengths are appropriate for use with singlemode fiber?
A. 650 & 850 nm
B. 850 & 1300 nm
C. 850 & 1310 nm
D. 1310 & 1550 nm
- _____ 5. The diameter of the core in OM2 and OM3 multimode fiber is how large?
A. 50 microns
B. 62.5 microns
C. 62.5 mm
D. 9 mm
- _____ 6. Which of the following fiber specifications is most important to the user and is an important factor in testing?
A. Attenuation
B. Bandwidth
C. Numerical aperture
D. Core-cladding concentricity
- _____ 7. The largest contributor to fiber attenuation is _____.
A. Absorption
B. Scattering
C. Bending losses
D. Microbends

- _____ 8. Which fiber typically has the largest core?
- A. POF
 - B. Multimode Step Index
 - C. Multimode Graded Index
 - D. Singlemode
- _____ 9. The loss of a singlemode fiber is lowest at _____.
- A. 850 nm
 - B. 1300 nm
 - C. 1310 nm
 - D. 1550 nm
- _____ 10. Which type of dispersion affects singlemode fiber as well as multimode fiber?
- A. Modal
 - B. Differential
 - C. Chromatic
 - D. Polarization mode
- _____ 11. Which types of dispersion needs to be tested in long singlemode fiber links?
- A. Modal
 - B. Differential
 - C. Chromatic
 - D. Polarization mode

Chapter 5 Quiz
Answer Section

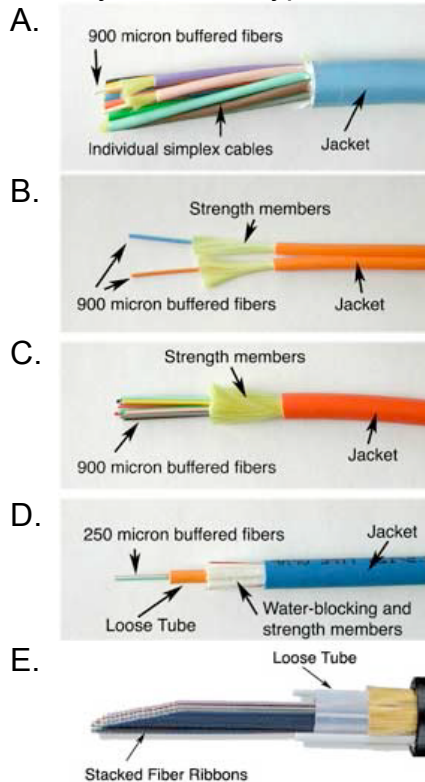
MULTIPLE CHOICE

1. ANS: A
Singlemode fiber cores are much smaller than multimode fibers so they only can carry one mode of light.
2. ANS: B
Typical singlemode fiber has a core size around 9 microns.
3. ANS: A
Since it carries only one mode, SM fiber suffers no modal dispersion which limits MM fiber and has much higher bandwidth.
4. ANS: D
SM fiber operates at 1310 and 1550 nm, and sometimes all the wavelengths around them.
5. ANS: A
OM2 and OM3 (laser-optimized) fiber has a 50 micron core.
6. ANS: A
Attenuation of the fiber contributes to the loss of the cable plant, along with connector losses.
7. ANS: B
Scattering is the major cause of fiber attenuation.
8. ANS: A
Most POF is large core step-index fiber, with a core ~1mm.
9. ANS: A
Scattering is higher at shorter wavelengths, causing fiber attenuation of about 0.4 dB/km at 1310 nm but only about 0.25 dB/km at 1550 nm. Usual SM fiber is not used at wavelengths below 1310 nm.
10. ANS: C
Chromatic dispersion, caused by the fact that the speed of light in glass is a function of wavelength, affects both SM and MM fiber.
11. ANS: C, D
Chromatic dispersion and polarization mode dispersion require testing in very long SM links.

Chapter 6 Quiz – Fiber Optic Cable

Matching

Identify the cable types



- _____ 1. Zipcord
- _____ 2. Distribution
- _____ 3. Loose tube
- _____ 4. Ribbon
- _____ 5. Breakout

True/False

Indicate whether the statement is true or false.

- _____ 6. Any cable that contains metallic conductors must be properly grounded and bonded.
- _____ 7. In order to specify a fiber optic cable properly, you need to specify installation specifications as well as environmental specifications.

Multiple Choice

Identify the choice that best completes the statement or answers the question.

- _____ 8. Cables which contain both multimode and singlemode fibers are called _____.
- A. Mixed cables
 - B. Hybrid cables
 - C. Composite cables
 - D. XC cables
- _____ 9. Aerial cables must be designed and installed to withstand _____.
- A. Continual tension from cable weight
 - B. Wind
 - C. Ice
 - D. All of the above
- _____ 10. No cable should be installed indoors unless it _____.
- A. Is UL listed for flame retardancy for NEC
 - B. Is colored orange to indicate fiber optics
 - C. Is enclosed in innerduct or conduit
 - D. The length is printed on the cable jacket
- _____ 11. Loose tube cable requires a _____ to terminate directly with connectors, so often pigtailed are spliced-on instead.
- A. Splice closure
 - B. Breakout kit
 - C. Strain relief
 - D. Tube stuffer
- _____ 12. Armored cable is used in outside plant installations to _____ and _____.
- A. Loose tube
 - B. Ribbon
 - C. Tight buffer
- _____ 13. The minimum long term bend radius of installed fiber optic cable is usually specified as no less than _____.
- A. 12 inches
 - B. 1 meter
 - C. 10 times the cable diameter
 - D. 20 times the cable diameter
- _____ 14. Black polyethylene jackets are used on outdoor cables for _____.
- A. Abrasion resistance
 - B. High tensile load
 - C. Sunlight and moisture resistance
 - D. Appearance

Chapter 6 Quiz
Answer Section

MATCHING

1. ANS: B
2. ANS: C
3. ANS: D
4. ANS: E
5. ANS: A

TRUE/FALSE

6. ANS: T
Conductive cables must be grounded and bonded for electrical safety per electrical codes.
7. ANS: T
Installation specs will include pulling tension or aerial cable tension while the environment will cover temperature, moisture, etc.

MULTIPLE CHOICE

8. ANS: B
Sometimes confused with composite cables which have copper conductors and fiber.
9. ANS: D
Aerial cables are designed to withstand the tension caused by cable weight as well as loads from wind and ice accumulation.
10. ANS: A
All indoor cables must be rated for flame retardance for the NEC to pass building inspections.
11. ANS: B
Breakout kits are used to sleeve the 250 micron fiber to 900 micron diameter (same as tight buffered fiber) so a connector can be attached without fiber damage.
12. ANS: A, B
Armor in cable will prevent rodent damage but also protect the fibers from crushing loads when buried underground.
13. ANS: D
Long term bend radius is 10 times the cable diameter while under tension as when being pulled, it is 20 times the cable diameter.
14. ANS: C
PE resists water and the black color resists sunlight.

Chapter 7 Quiz – Splices and Connectors

True/False

Indicate whether the statement is true or false.

- _____ 1. Most singlemode field terminations are made by fusion splicing a factory-made pigtail onto the cable.
- _____ 2. The SC and LC connectors have different size ferrules and cannot be mated.

Multiple Choice

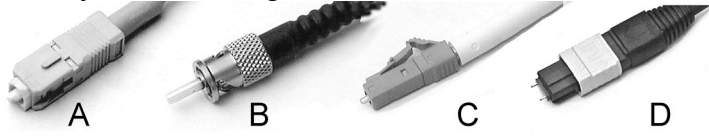
Identify the choice that best completes the statement or answers the question.

- _____ 3. The loss of a fiber optic connector is defined as _____?
- A. The calculated loss due to geometric misalignment
 - B. The loss of the connector mated to another connector
 - C. One-half the loss of a mated pair of connectors
 - D. The loss of a statistical sample of connectors
- _____ 4. Field terminations of singlemode fibers are generally done by _____ ?
- A. Adhesive/polish method
 - B. Heat-cured anaerobic adhesive
 - C. Prepolished/splice connectors with mechanical splices
 - D. Fusion splicing a factory terminated pigtail onto the fiber
- _____ 5. Factory terminations, such as used for making patchcords, generally use what method of attaching the connector to the cable?
- A. Epoxy/polish
 - B. Anaerobic adhesive
 - C. Prepolished/splice
 - D. Any of the above
- _____ 6. From a reliability standpoint, _____ is the best method to join two fibers.
- A. Mechanical splicing
 - B. Fusion splicing
 - C. Adhesive/polish connectors
 - D. Factory terminations
- _____ 7. The difference between a fiber optic connector and a splice is _____.
- A. Connectors are larger than splices
 - B. Connectors are demountable, while splices are permanent
 - C. Connectors require adhesives
 - D. Splices need expensive tools

- _____ 8. Which one of the following performance requirements are not shared by connectors and splices?
- A. Low loss
 - B. Low back reflection
 - C. Repeatability
 - D. Durability under repeated matings
- _____ 9. In singlemode connectors, _____ is as important as low loss.
- A. Ease of field termination
 - B. Low reflectance
 - C. Low cost
 - D. Compatibility with many cable types
- _____ 10. Both mechanical splices and prepolished/splice connectors require a good _____ to have low loss.
- A. Field polishing technique
 - B. Cleave on the fiber being terminated
 - C. Fiber loss
 - D. Cable design
- _____ 11. Physical contact (PC) polish on connectors is designed to reduce _____.
- A. Loss
 - B. Reflectance
 - C. Loss and reflectance
 - D. Polishing time
- _____ 12. Preparing cables for splicing in splice closures requires _____.
- A. Leaving the proper length of buffer tubes from the cable entrance in the closure to the splice tray
 - B. Leaving the proper length of fiber to splice and fit the splice in the splice tray
 - C. Securing the cable properly at the closure entrance
 - D. All of the above
- _____ 13. Individual splice loss on concatenated cables can be verified by _____.
- A. OTDR testing
 - B. Insertion loss testing
 - C. Visual fault location
 - D. Visual inspection

Matching

Identify the following connectors:



- _____ 12. ST
- _____ 13. SC
- _____ 14. LC
- _____ 15. MTP

Chapter 7 Quiz
Answer Section

TRUE/FALSE

1. ANS: T
Terminating singlemode is difficult in field conditions so they are generally made by fusion splicing factory made pigtailed onto the fibers.
2. ANS: T
SC has a 2.5 mm ferrule and the LC a 1.25 mm ferrule, making alignment impossible.

MULTIPLE CHOICE

3. ANS: B
It's really "connection loss" – the loss of the connection made by the mating of two fibers in connectors.
4. ANS: D
Field terminations of singlemode fibers are hard to get good loss and low reflectance so most terminations are made by fusion splicing pigtailed made in a factory to the installed cable.
5. ANS: A
Most factory-made terminations are epoxy-polish type as they are the most reliable and least expensive.
6. ANS: B
Fusion splicing yields the lowest loss and reflectance, plus highest reliability.
7. ANS: B
Connectors allow disconnecting and connecting multiple times while splices are permanent joints between two fibers.
8. ANS: D
Splices are permanent, so one looks for long term reliability instead of mating durability.
9. ANS: B
Singlemode systems are generally sensitive to reflectance.
10. ANS: B
Cleaving the fiber properly is the key to good splices.
11. ANS: C
The PC finish reduces both loss and reflectance.
12. ANS: C
All are important to make a neat and reliable closure.
13. ANS: A
Only an OTDR can measure the loss of an individual splice but bidirectional measurements are needed to get accurate measurements.

MATCHING

- 12. ANS: B
- 13. ANS: A
- 14. ANS: C
- 15. ANS: D

Chapter 8 Quiz - Fiber Optic Testing

True/False

Indicate whether the statement is true or false.

- _____ 1. Cables tested with an OTDR do not require insertion loss testing with a source and meter or OLTS.
- _____ 2. Connectors at each end of the cable plant should not be counted when calculating the cable plant loss.
- _____ 3. The OTDR should never be used without a "launch cable" which is also called a "pulse suppressor."

Multiple Choice

Identify the choice that best completes the statement or answers the question.

- _____ 4. Cable plant loss should be estimated during the _____ phase.
A. Design
B. Installation
C. Testing
D. Troubleshooting
- _____ 5. The standard method of testing installed singlemode cables in a cable plant is described in:
A. FOTP-34
B. ISO 11801
C. FOTP-57
D. OFSTP-7
- _____ 6. What test instrument(s) are used for insertion loss testing.
A. OLTS or light source and power meter
B. VFL
C. OTDR
- _____ 7. Singlemode graded-index glass fiber optic cables are tested with _____ sources at _____ and _____ wavelengths.
A. LED, 650, 850 nm
B. LED, 850, 1300 nm
C. Laser, 980, 1400 nm
D. Laser, 1310, 1550 nm
- _____ 8. What type of source is used for testing multimode fibers?
A. LED
B. VCSEL
C. Laser

- _____ 9. How many methods are included in standards for setting the "0 dB" reference for loss testing?
- A. One
 - B. Two
 - C. Three
 - D. Four
- _____ 10. Patchcords can be tested to verify the connectors on each end individually by _____?
- A. Single-ended testing
 - B. Double-ended testing
 - C. OTDRs
 - D. Visual fault locators
- _____ 11. Reference cables must match the _____ of the cables being tested.
- A. Fiber size and type
 - B. Fiber size and connector type
 - C. Connector type
 - D. Fiber size and loss specification
- _____ 12. The total loss of the fiber in the cable plant is calculated by multiplying the attenuation coefficient of the fiber by the _____.
- A. Length
 - B. Number of links
 - C. Number of connectors
 - D. Number of splices
- _____ 13. The principle of operation of OTDRs is similar to _____.
- A. Power meters and sources
 - B. Radar
 - C. Mirrors
 - D. Lenses
- _____ 14. OTDRs are used in outside plant cables to _____.
- A. Verify splice loss
 - B. Measure length
 - C. Find faults
 - D. All of the above
- _____ 15. In long distance applications, OTDR distance measurement accuracy is limited by their _____.
- A. Output power
 - B. Distance capability
 - C. Calibration of fiber index of refraction
 - D. Software

- _____ 16. Chromatic dispersion can be tested using an OTDR because _____.
- A. An OTDR can measure the round trip time differences at each wavelength
 - B. Chromatic dispersion affects backscatter
 - C. The OTDR receiver is sensitive to the wavelength of light
 - D. OTDRs test at multiple wavelengths
- _____ 17. In long distance applications intended for wavelength division multiplexing, a _____ test is used to verify fiber performance over all wavelengths.
- A. Dispersion
 - B. Spectral attenuation
 - C. OTDR
 - D. VFL

Chapter 8 Quiz
Answer Section

TRUE/FALSE

1. ANS: F
OTDR testing is not acceptable in place of insertion loss testing in standards due to its different test method.
2. ANS: F
Connectors on the ends of the cables must be included in loss budgets since they will be included in insertion loss tests.
3. ANS: T
The launch cable allows the OTDR to see beyond its dead zone and measure the first connector on a cable.

MULTIPLE CHOICE

4. ANS: A
Before installing or testing cables, it's important to know what the projected loss will be to ensure the systems will operate over the fiber and the acceptable loss is known for testing.
5. ANS: D
OFSTP-7 is the standard for installed SM cable testing.
6. ANS: A
Insertion loss requires a light source at one end and a power meter at the other.
7. ANS: D
SM fiber requires testing at the two prime wavelengths of use, 1310 and 1550 nm, plus sometimes it is also tested at special wavelengths used in fiber amps and DWDM at 1490 and 1620 nm.
8. ANS: C
Systems on multimode fiber may use LED or laser sources, but testing is done with LEDs since they can be mode-conditioned for more repeatable testing.
9. ANS: C
The "0 dB" reference can be set with one, two or three reference cables.
10. ANS: A
Single-ended testing allows testing the connector on each end of the cable individually.
11. ANS: B
The fiber in reference cables must be the same as those in the cable being tested and connectors must be compatible.
12. ANS: A
Attenuation in dB/km times the number of km of length equals loss in dB.

13. ANS: B
By sending out a high-power signal and looking for returned scattered and reflected power, the OTDR works like an optical RADAR.
14. ANS: D
OTDRs can verify splice loss, measure length and find faults in installed cables.
15. ANS: C
The index of refraction is used to calculate the distance as it determines the speed of light in the fiber.
16. ANS: A
The index of refraction is different for each wavelength so the OTDR can calculate the dispersion as it measures the distance in the fiber.
17. ANS: B
Spectral attenuation measures the attenuation of the fiber over a range of wavelengths used in WDM.

Chapter 9 Quiz – Fiber Optic Network Design

True/False

Indicate whether the statement is true or false.

- _____ 1. Fiber optic network designers should have a knowledge of electrical power systems and hardware as well as communications design.
- _____ 2. The first consideration for any network is choosing the proper fiber optic cable type.
- _____ 3. Discussions of which is better – copper, fiber or wireless – are no longer relevant, as fiber is the only choice.
- _____ 4. It may be more cost effective for the fiber optic cabling in many projects to be custom designed and made.
- _____ 5. Testing a fiber optic installation may require testing three times, cable before installation, each segment as installed and a final test of end-to-end loss.

Multiple Choice

Identify the choice that best completes the statement or answers the question.

- _____ 6. Fiber optic network designers should have an in-depth knowledge of _____.
A. Fiber optic components and systems
B. Installation processes
C. All applicable standards, codes and any other local regulations
D. All of the above
- _____ 7. The first requirement that must be considered for a new fiber optic project is _____.
A. The customer's communications system requirements
B. Where the cable plant will be run
C. Whether it will be multimode or singlemode fiber
D. The customer's budget
- _____ 8. Fiber Optic Network design involves _____.
A. Determining the types of communications systems involved
B. Planning the routes for all cabling or wireless
C. Choosing appropriate cabling and media
D. All of the above
- _____ 9. When choosing components, most projects will start with the choice of a _____.

- A. Cable
- B. Splice type
- C. Connector
- D. Cable hardware

_____ 10. Most premises networks today should use _____ multimode fiber but backbone cables can contain _____ fibers for future expansion.

- A. OM1, OM3
- B. OM1, singlemode
- C. OM3, singlemode
- D. OM2, OM3

_____ 11. _____ of the cable plant is a necessary part of the design and installation process for a fiber optic network that is often overlooked.

- A. Planning
- B. Documentation
- C. CAD-CAM drawing
- D. OTDR testing

_____ 12. What is the most helpful information you can have when trying to troubleshoot a cabling network for restoration?

- A. Phone number of a fiber optic contractor
- B. Loss data on each fiber
- C. OTDR traces
- D. Documentation

Multiple Response

Identify one or more choices that best complete the statement or answer the question.

_____ 13. Metropolitan networks can involve which of the following systems?

- A. CCTV surveillance cameras
- B. Traffic monitoring
- C. Emergency services
- D. Educational systems

Chapter 9 Quiz
Answer Section

TRUE/FALSE

1. ANS: T
The fiber optic network designer must be familiar with electrical power systems, since the electronic hardware must be provided with high quality uninterruptible power at every location.
2. ANS: F
Before one can begin to design a fiber optic cable plant, one needs to establish with the end user or network owner where the network will be built and what communications signals it will carry.
3. ANS: F
While discussions of which is better – copper, fiber or wireless – has enlivened cabling discussions for decades, it's becoming moot. Communications technology and the end user market, it seems, have already made decisions that generally dictate the media and many networks combine all three.
4. ANS: T
Most projects start with the choice of a cable. Since OSP applications often use significant lengths of cables, the cables can be made to order, allowing optimization for that particular installation.
5. ANS: T
The process of testing any fiber optic cable plant may require testing three times, testing cable on the reel before installation, testing each segment as it is installed and finally testing complete end to end loss of every fiber in the cable plant.

MULTIPLE CHOICE

6. ANS: D
These are all important areas for the knowledgeable fiber optic network designer.
7. ANS: A
Any communications network must first be considered from the standpoint of the communications it should be transmitting.
8. ANS: D
Fiber optic network design involves all of the above and more!
9. ANS: A
The choice of the cable usually comes first since the cable must be chosen for the type of installation and the choice of most other hardware will depend on the cable chosen.
10. ANS: C

As in OSP design, consider the fiber choice first. Most premises networks use multimode fiber, but many users now install hybrid cables with singlemode fibers for future expansion. The 62.5/125 micron fiber (OM1 fiber) that has been used for almost two decades has mostly been superseded by the new 50/125 laser-optimized fiber (OM3), as it offers substantial bandwidth/distance advantages.

11. ANS: B
Documentation of the cable plant is a necessary part of the design and installation process for a fiber optic network that is often overlooked.
12. ANS: D
Documentation is the most helpful thing you can have when trying to troubleshoot a fiber network, especially during restoration.

MULTIPLE RESPONSE

13. ANS: A, B, C, D
Metropolitan networks owned and operated by cities can carry a variety of traffic, including surveillance cameras, emergency services, educational systems, telephone, LAN, security, traffic monitoring and control and sometimes even traffic for commercial interests using leased bandwidth on dark fibers or city-owned fibers.

Chapter 10 Quiz – Fiber Optic Installation

True/False

Indicate whether the statement is true or false.

- _____ 1. One should be able to rely the contractor to not only do the installation but to assist in the design of the network and help choose components and vendors.
- _____ 2. All metal components of the cabling system installed in a equipment or telecom room must be grounded and bonded.
- _____ 3. A single outside plant link may include several types of installation, including aerial, buried and underground.

Multiple Choice

Identify the choice that best completes the statement or answers the question.

- _____ 4. _____ will facilitate installation, allow better planning for upgrades and simplify testing.
A. Good workmanship
B. Low loss connectors
C. Safe workplace procedures
D. Proper documentation
- _____ 5. Outside plant cabling can be installed by _____.
A. Pulling in underground in conduit
B. Direct burial
C. Aerial suspension
D. All of the above
- _____ 6. The protective gear every VDV installer must always wear is _____.
A. Eye protection
B. Plastic apron
C. Gloves
D. Shoe covers
- _____ 7. The fiberglass rod inside many fiber optic cables is for _____.
A. Increasing the pulling tension
B. Limit bend radius to preventing kinking
C. Winding the fibers around
D. Tying to messenger cables
- _____ 8. To prevent the cable from twisting when pulling it _____.
A. Use a swivel eye

- B. Pull with braided rope
- C. Spin the cable off the spool
- D. Lubricate the cable

_____ 9. On long pulls, at intermediate points, why do you lay the cable in a "figure 8"?

- A. Keep it from getting tangled with the pull rope
- B. Make it easier to spray on lubricant
- C. Keep workers from walking on it
- D. Prevent it from twisting

_____ 10. Under pulling tension, the bend radius should not be less than _____.

- A. 5 times the cable diameter
- B. 10 times the cable diameter
- C. 20 times the cable diameter
- D. 50 times the cable diameter

_____ 11. Underground cables are pulled in conduit that is buried underground, usually _____ deep to reduce the likelihood of accidentally being dug up. .

- A. 3-4 feet (1-1.2 meters)
- B. 1-2 feet (0.3-0.5 meter)
- C. 6-8 feet (2-2.5 meters)
- D. As deep as the local building codes allow

_____ 12. Long cable pulls in conduit may require _____ or _____ and your installers need to know how to "figure 8" cable to prevent kinking,.

- A. Heavy-duty mechanical pullers
- B. Trucks or tractors to pull the cable
- C. Lubricants
- D. Intermediate pulls

_____ 13. Most fiber optic cables do not have sufficient strength to allow direct aerial installation, but _____ or _____ can be used to install them aerially.

- A. Rubber clamps
- B. Pole-mounted grips
- C. Lashing to another cable
- D. Lashing to messenger strands

_____ 14. Cable ties used on fiber optic cables _____.

- A. Should be tightened firmly to prevent cable movement
- B. Can be used to hang cables from J-hooks or cable trays
- C. Should be rated for the weight of the cables
- D. Can harm cables if too tight, so they should be hand-tightened

_____ 15. Where the _____ is appropriate, direct burial installation allows for fast installation.

- A. Local permit
- B. Ground

- C. Cost
- D. Cable

_____ 16. Aerial cables are subject to continual tension as well as extra tension caused by _____, _____ and in some areas _____.

- A. Temperature changes
- B. Wind
- C. Rain
- D. Weight of ice

_____ 17. Each completed splice on an installed cable should be tested with an _____, preferably immediately after it is spliced.

- A. OLTS
- B. OTDR
- C. VFL
- D. CD test set

_____ 18. If at all possible, _____ before installing any other cables on utility poles. .

- A. Look for other installation options
- B. Have the power cables shut down
- C. Notify the proper authorities
- D. Notify the owners of other cables

Chapter 10 Quiz
Answer Section

TRUE/FALSE

1. ANS: T
The contractor should have experience in a fiber optic project from design through final testing and be able to assist the customer in all aspects of the project.
2. ANS: T
For electrical safety, all conductive parts of the system, including hardware, must be properly grounded and bonded.
3. ANS: T
It's not uncommon for an OSP link to have several types of installation processes.

MULTIPLE CHOICE

4. ANS: D
Good documentation helps everywhere, even after the completion of the project for restoration.
5. ANS: D
OSP cables are installed in all these ways which are quite different in process.
6. ANS: A
Every part of the installation process involves hazards to the eyes. Eye protection is needed for all installers, particularly to prevent fiber scraps from harming the eyes.
7. ANS: B
The primary use for the fiberglass rod in the center of the cable is to limit the bend radius to prevent kinking, but use as a strength member, along with the aramid fiber strength members, is a secondary use.
8. ANS: A
Pulling ropes sometimes unwind under tension so the swivel prevents it causing cable twists.
9. ANS: D
Each coil in the "figure 8" puts a half-twist into the cable then does a half-twist in the opposite direction to remove any twisting.
10. ANS: C
The guidelines are 20 times the cable diameter under tension, 10 times under no pulling tension.
11. ANS: A
Most cables are installed about 3 feet or 1 meter underground to protect the cable. A marker tape is usually buried above the cable.
12. ANS: C, D

Lubricants reduce friction to reduce pulling tension. Intermediate pulls are used when even lubrication reaches its limits.

13. ANS: C, D
Regular OSP cable can be lashed to a messenger or another cable for support in aerial applications.
14. ANS: D
Tightening cable ties can put harmful stress on the fibers (or pairs in UTP copper cables), so hand tighten them and cut off the excess length. Even better, use soft "hook and loop" ties that can be reopened to move cables.
15. ANS: B
Direct burial requires the ground be relatively easy to plow or trench and not have a large number of rocks.
16. ANS: A, B, D
Under temperature changes, the cable will expand and contract causing changes in tension. Wind and, in cold climates, ice also affect cable loading.
17. ANS: B
While most fusion splicers give an estimate of splice loss, only an OTDR can verify the actual loss, although it needs bidirectional testing to get higher accuracy.
18. ANS: B
Working around power lines can be dangerous, even with all dielectric fiber optic cable because the hardware may be conductive and the installer may be in close proximity to the power cables. With notice, most power companies will cooperate.