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FOA Reference Guide To Fiber Optics

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.thefoa.org/tech/ref/) 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. However, the production of this book is done by "publishing on demand," where the book is not printed until ordered, and only after accessing the latest version electronically. Thus this edition meets the needs of those who prefer printed references without burdening them with trying to determine what material is already obsolete.

For those who want this printed version but also want access to the web for color graphics, automatic self-testing or links to even more technical information, we have provided links on the FOA Online Reference Guide website to the appropriate sections covered in this book.

Guide to *The FOA Reference Guide to Fiber Optics*
and *The FOA Online Reference Guide to Fiber Optics*

The FOA Reference Guide to Fiber Optics and *The FOA Online Reference Guide to Fiber Optics* were created as an updated alternative to the FOA textbook *The Fiber Optic Technicians Manual* for training designers and installers of fiber optic networks. It only includes a short introduction to the basics of fiber optics, 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 from the training programs developed by a number of other professional 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 large 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, components, installation and testing, to give the reader a complete, concise section to learn about the technology. This section is a concise summary of the material that is covered in the CFOT exam. They are then divided into additional sections that cover all the relevant 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 and the website are similar to the material in The Fiber Optic Technicians Manual (FOTM). For those who also have the textbook and are also using the online reference guide, the correlations between online reference topics in “ Fiber Optics, The Basics” and the book chapters are included.

Chapter Guide for The FOA Reference Guide to Fiber Optics
Chapter numbers refer to the Textbook
ORG = FOA Online Reference Guide To Fiber Optics
FOTM = Fiber Optic Technicians Manual

Chapter 1, Introduction to Fiber Optics
ORG, Basic Overview
(FOTM Chapter 2)

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, The Jargon and the Technology
(FOTM All Chapters)

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 most important section, as a basic understanding of the terms used will make the rest of the material much easier to comprehend.

Chaptter 3, Fiber Optic Applications and Communications Systems
ORG, Basic Applications and Transmission Systems
(FOTM Chapter 3)

In this chapter, network applications for telecom, CATV and various local area networks (LANs) are described. Fiber's role in each of the networks is covered in detail, in relation to the copper wiring still used in many of them. 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, Applications, Communications, Fiber Optic Datalinks, Fiber Optic Transceivers for Datalinks
(FOTM Chapters 2, 4, 5)
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.

Chapter 5, Optical Fiber
ORG, Optical Fiber
(FOTM Chapters 2, 4, 5)
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. 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 Cables
ORG, Cables
(FOTM Chapters 4, 5)
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 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, Fiber Optic Connectors, Splicing and Hardware
ORG, Termination and splicing
(FOTM Chapters 6, 7)
This is an overview of termination and splicing types and techniques. The student should physically examine samples of the most popular connectors (ST, SC, LC) if possible but the page includes photos of most types. You 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.
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.

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

Chapter 8, Fiber Optic Testing
ORG, Testing
(FOTM Chapter 17)

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. This section includes the basics of testing but supplemental tutorials cover actual processes.

Supplemental reading: 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, Network Design
(FOTM Chapters 9, 10, 12, 13, 14)

This chapter covers only an overview of 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, Installation: (FOTM Chapters 9, 11, 12, 15, 16)

The topic of fiber optic cable plant installation is a very diverse subject, since fiber is used in so many different types of 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: Installation of FO Cable Plants. Read topics of interest to you plus "Safety Procedures" and "Cleaning Fiber Optic Connections."

Additional Reference Materials On *The FOA Online Reference Guide*

While the section Fiber Optics, The Basics covers the primary information covered in the classroom of most fiber optic courses and in the CFOT exam, we have provided

much additional material 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.

ORG, Standards
(FOTM Appendix B)
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.

ORG, Glossary of Terms
(FOTM Appendix A)
This section is provided for reference purposes and as an elaboration to the Jargon section.

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, temination 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 thorugh maintenance and rstoration, is a major issue for owners of the systems and their contractors.

Future Reference Usage

Studying the sections under Fiber Optics, The Basics, reading supplemental materials relevant to your interests and work and correctly answering the section quizzes will prepare you for the CFOT exam. As a CFOT, you will have unlimited access to this website 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 cell phone, most of the site has been designed to be viewable from one those devices.

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 pigtailled 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 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 (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. In an industrial environment, fiber is most often used to
A. Prevent electromagnetic interference
B. Provide ultra-high speed connections to machines
C. Withstand high temperatures
D. Tolerate physical abuse

____ 4. Which of the following are not necessary in a centralized fiber optic cabling architecture?
A. Repeaters or hubs
B. Telecom closets
C. Wall outlets
D. NIC cards

____ 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 typicall 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
   Electrical interference is a problem in many industrial applications and fiber's immunity to EMI is important.
4. ANS: B
   Centralized fiber networks have all the electronics in the computer room and at the user location. No intermediate hubs or switches are required, so no telecom closet (or room as they call it now) is necessary.
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. Multimode fiber systems operation at speeds of 1 Gb/s or more use ____ sources.
A. LED
B. VCSEL
C. F-P laser
D. DFB laser

____ 4. The _____ of a laser makes the effective bandwidth of multimode fiber higher than with LEDs.
A. Restricted modal launch
B. Higher power
C. Lower power
D. Bandwidth

____ 5. Short wavelength 850 nm links can use _____detectors in the receiver.
A. Silicon
B. Germanium
C. InGaAs

____ 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
   As many premises systems using multimode fiber have exceeded bit rates of 1 Gb/s, lasers (mostly VCSELs) have replaced LEDs.
4. ANS: A
   The restricted launch of the VCSEL or any laser makes the effective bandwidth of the fiber higher, but laser-optimized fiber, usually OM3, is the choice for lasers.
5. ANS: A
   Silicon photodiodes are used for short wavelength links (650 for POF and 850 for glass MM fiber).
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 Ffiber

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 multimode 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 multimode graded index fiber is greatest 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

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 cor 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: B
   MM fiber operates at 850 and 1300 nm, while singlemode fiber is optimized for 1310 and 1550 nm.
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 iber 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 3 dB/km at 850 nm but only 1 dB/km at 1300 nm. MM fiber is rarely used at 1550 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.

Chapter 6 Quiz – Fiber Optic Cable

Matching

True/False
Indicate whether the statement is true or false.

____ 1. Any cable that contains metallic conductors must be properly grounded and bonded.

____ 2. 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.

____ 3. Cables which contain both multimode and singlemode fibers are called:
A. Mixed cables
B. Hybrid cables
C. Composite cables
D. XC cables

____ 4. Cables with metallic conductors as well as fiber are called:
A. Mixed cables
B. Hybrid cables
C. Composite cables
D. XC cables

____ 5. 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

____ 6. ALL outdoor cables are specifically designed to:
A. Include large numbers of fibers
B. Be direct buried for ease of installation
C. Prevent rodent damage to the cable
D. Prevent moisture damage to the fiber

____ 7. The design of cables of small size with very large fiber counts is usually:
A. Loose tube
B. Ribbon
C. Tight buffer

____ 8. The design of cables for high pulling tension in outside plant installations is usually:
A. Loose tube
B. Ribbon
C. Tight buffer

____ 9. The advantage of a breakout cable over a distribution cable is:
A. The breakout cable has a smaller size and weight
B. The breakout cable can be installed and terminated without additional hardware for protection of the terminations
C. Breakout cable costs less than distribution cable
D. Breakout cable can be used indoors or outdoors

____ 10. Cables should always be pulled with _____ to prevent damage.
A. Nylon rope
B. Kellums grip on the jacket
C. Tension gage
D. The cable's strength members

____ 11. Loose tube cable requires a _____ to terminate with connectors
A. Splice closure
B. Breakout kit
C. Strain relief
D. Tube stuffer

____ 12. Armored cable is used in outside plant installations to _____.
A. Prevent rodent damage
B. Protect from damage from dig-ups
C. Increase pulling tension
D. Conduct lightning strikes

____ 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

TRUE/FALSE

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

MULTIPLE CHOICE

3. ANS: B
   Sometimes confused with composite cables which have copper conductors and fiber.
4. ANS: C
   Sometimes confused with hybrid cables which have both SM and MM fibers.
5. ANS: A
   All indoor cables must be rated for flame retardance for the NEC to pass building inspections.
6. ANS: D
   Moisture is a problem in all outdoor cables, while the other choices may apply in certain circumstances.
7. ANS: B
   Ribbon cables pack the most fibers into the smallest cable.
8. ANS: A
   Loose tube cables allow for the greatest pulling tension.
8. ANS: B
   Breakout cable is just a jacketed bundle of simplex cables which are easy to terminate and require no additional hardware for protection.
10. ANS: D
    All cables are designed to be pulled with the strength members, usually aramid yarn, not the jacket.
11. ANS: B
    The 250 micron buffered fibers are too fragile to work with until sleeved with furcation tubes in a breakout kit.
12. ANS: A
    Armor provides protection from rodent penetration.
13. ANS: C
    When not under tension, the cable should withstand bending on a radius 10 times the cable diameter. Under tension, it's 20 times.
14. ANS: C

PE resists water and the black color resists sunlight.

Chapter 7 Quiz – Fiber Optic Connectors and Splices

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. TheSC and LC connectors have different size ferrules and cannot me mated.

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

____ 3. The first version of TIA/EIA 568 standard for premises cabling called for the use of which connector?
A. ST
B. SC
C. LC
D. Any with a FOCIS standard

____ 4. What connector style is now specified in the latest 568 standard (568B.3)?
A. SC
B. LC
C. MT-RJ
D. Any connector with a FOCIS document

____ 5. Factory terminations, such as used for making patchcords, 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. What is needed to get low loss from a prepolished/splice connector?
A. Good stripping technique
B. Good cleave
C. Gentle crimp
D. Proper cable type

____ 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

Matching

Identify the following connectors:

A. 

B. 

C. 

D. 

____ 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 pigtails 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
   The first connector standardized by TIA-568 was the SC but now any connector with a FOCIS document is allowed.
4. ANS: D
   The first connector standardized by TIA-568 was the SC but now any connector with a FOCIS document is allowed.
5. ANS: A
   Most factory-made terminations are epoxy-polish type as they are the most reliable and least expensive.
6. ANS: B
   The splice in the prepolished connector must be well made and that requires a good cleave on the fiber.
7. ANS: B
   Connectors allow disconnecting and connecting multiple times while splices are permanent.
8. ANS: D
   Splices are permanent, so one looks for long term reliability instead.
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.

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 multimode cables in a cable plant is described in:
A. FOTP-34
B. ISO 11801
C. FOTP-57
D. OFSTP-14

____ 6. What test instrument(s) are used for insertion loss testing.
A. OLTS or light source and power meter
B. VFL
C. OTDR

____ 7. Multimode 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 singlemode 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. Which reference method is required for TIA 568?
A. Once cable reference
B. Two cable reference
C. Three cable reference
D. Any method as long as it is documented

____ 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 premises applications, OTDRs are limited in usefulness by their _____.
A. Output power
B. Distance capability
C. Distance Resolution
D. Software

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 differen t 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-14 is the standard for MM cable testing.
6. ANS: A
   Insertion loss requires and light source at one end and a power meter at the other.
7. ANS: B
   MM fiber is usually tested with sources similar to the systems that will use the fiber, LEDs at 850 or 1300 nm. Although some systems at gigabit speeds used VCSEL lasers, testing is still done with LEDs.
8. ANS: C
   Systems on singlemode fiber use laser sources, so testing is done with lasers.
9. ANS: C
   The "0 dB" reference can be set with one, two or three reference cables.
10. ANS: D
    TIA-568 originally called for a one cable reference but it's not always feasible, with multifiber plug and jack connectors, for example, so any of the three methods are OK as long as they are documented with the test data.
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
    Their inability to resolve short cables makes OTDRs of limited use in premises systems.

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. Most building management systems use _____ cabling.
A. Fiber optic

B. Coax
C. Structured
D. Proprietary copper

____ 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 monitoriing
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: D

Most building management systems use proprietary copper cabling, for example thermostat wiring and paging/audio speaker systems. Security monitoring and entry systems, certainly the lower cost ones, still depend on copper, although high security facilities like government and military installations often pay the additional cost for fiber's more secure nature.

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 superceded 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. Industrial applications often use fiber optics for its noise immunity rather than distance and bandwidth advantages.

____ 2. All metal components of the cabling system installed in a equipment or telecom room must be grounded and bonded.

____ 3. When upgrading cables in a telecom closet, old, abandoned cables can be cut back to the wall and left in place, as long as the firestopping is not disturbed.

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. The industry standard that covers structured cabling, both fiber and copper, is _____.
A. TIA-568
B. TIA-526-14
C. IEEE 802.3
D. NECA-301

____ 12. Structured cabling installed to TIA-568 standards uses a _____ cabling architecture.
A. Bus
B. Ring
C. Star
D. Tree

____ 13. Vertical cable runs should preferably be installed by _____.
A. Pulling slowly and carefully by hand
B. Calibrated pulling machines
C. Pulling one floor at a time
D. Dropping from above rather than pulling up

____ 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

Chapter 10 Quiz
Answer Section

TRUE/FALSE

1. ANS: T
   Electrical noise is often a problem in industrial applications and fiber's immunity is most important.
2. ANS: T
   For electrical safety, all conductive parts of the system, including hardware, must be properly grounded and bonded.
3. ANS: F
   NEC requires removal of abandoned cables as fire hazards.

MULTIPLE CHOICE

4. ANS: D
   Cable documentation should be started before installation so the installation is properly documented and ready for labelling and recording test data. Documentation will facilitate installation, allow planning for upgrades and provide data needed for restoration.
5. ANS: D
   OSP cables are installed in all these ways which are quite different in process.
6. ANS: A
   Eye protection is needed for all installers to prevent fiber scraps from harming the eyes.
7. ANS: B
   The rod stiffens the cable to prevent kinking.
8. ANS: A
   Pulling ropes sometimes unwind upder 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 diamter under tension, 10 times under no pulling tension.
11. ANS: A
    TIA 568, the standard for commercial cabling, covers fiber and copper cabling.
12. ANS: C
    The TIA-568 star architecture supports LAN architectures and most other types of equipment connections.

13. ANS: D
    Dropping cables from above reduces the stress on the cable and is easier on the installer.
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.