Certified Fiber Optics Technician (FOT)
Competency Requirements

This Fiber Optics Technician (FOT) competency listing is the syllabus or objective of each individual subject item in which a fiber optics technician (FOT) must be knowledgeable and/or skilled to prepare for the hands-on course training and the ETA® International FOT certification knowledge examination. The competency includes concepts of fiber optics servicing, troubleshooting and repairing; diagnostically ranging from the intermediate installation up to rudimentary design knowledge.

A fiber optics technician (FOT) must hold the FOI certification as a pre-requisite and in addition to completing a special course, fee and hands-on skills exam from an ETA approved school must also be knowledgeable in the following technical areas:

1.0 PRINCIPLES OF FIBER OPTIC TRANSMISSION

- 1.1 Describe the basic parts of a fiber optic link
- 1.2 Describe the basic operation of a transmitter
  - 1.2.1 Graphically explain how Analog to Digital Conversion (A/D) is accomplished
- 1.3 Describe the basic operation of a receiver
  - 1.3.1 Graphically explain how Digital to Analog Conversion (D/A) circuitry works
- 1.4 Explain Amplitude Modulation (AM)
- 1.5 Compare Digital data transmission with Analog
- 1.6 Explain the difference between Pulse Coded Modulation (PCM) and AM
- 1.7 List the benefits of Multiplexing signals
- 1.8 Explain the purpose of decibels (dBs)
  - 1.8.1 Convert voltage and power levels to and from decibel equivalents
  - 1.8.2 Explain how to express gain or loss using dB
- 1.9 Explain how Optical Power is measured (dBm); express optical power levels in dBm's and compare power gains and losses

2.0 BASIC PRINCIPLES OF LIGHT

- 2.1 Describe the Electromagnetic Spectrum and locate light frequencies within the spectrum in relation to communications frequencies
- 2.2 Convert various wavelengths to corresponding frequencies
- 2.3 Describe how the Index of Refraction is calculated
- 2.4 Recall the phenomenon that makes fiber optic transmission possible, total internal reflection (TIR)
- 2.5 Define Fresnel Reflection Loss
- 2.6 Explain the effects of Refraction
  - 2.6.1 Explain Snell's Law

3.0 OPTICAL FIBER CONSTRUCTION AND THEORY

- 3.1 Name the materials out of which optical fiber core is manufactured
- 3.2 Discuss why the core and the cladding have different compositions of glass
- 3.3 State the materials from which the fiber optic coating is manufactured
- 3.4 Define the performance of optical fibers used in the telecommunications industry in accordance with Telecommunications Industry Association (TIA®), Telcordia, and the International Telecommunications Union (ITU®)
- 3.5 Summarize the fiber types that correspond to the referenced fiber designations OM1, OM2, OM3, OM4, OM5, OS1, and OS2 in accordance with ISO/IEC (the International Organization for Standardization/International Electrotechnical Commission) requirements
- 3.6 Describe single-mode fiber and how it differs from multimode fiber
  - 3.6.1 Explain why multimode fiber may be selected over single-mode fiber

3.7 List common material classifications for a fiber optic cable
3.8 Describe the basics of optical fiber manufacturing
3.9 Point out how the number of potential paths (modes) of light is one of the most important characteristics used to distinguish types of fiber
3.10 Distinguish the relationship and purpose between the different refractive index profiles

4.0 OPTICAL FIBER CHARACTERISTICS

4.1 Define dispersion in an optical fiber
4.2 Explain how modal dispersion causes pulses to spread out as they travel along the fiber
  4.2.1 List the methods for overcoming modal dispersion
4.3 Explain how material dispersion arises from the change in a material's refractive index with wavelength
4.4 Relate how waveguide dispersion is a separate effect from material dispersion, arising from the distribution of light between core and cladding
4.5 Explain chromatic dispersion in an optical fiber
4.6 Explain how polarization mode dispersion (PMD) affects the two distinct polarization mode states, referred to as differential group delay (DGD)
4.7 Describe how to measure fiber optic link attenuation using the referenced methods specified by TIA-526-14-B for multimode and TIA-526-7 for single-mode fiber optic cables
4.8 Describe how microbends can change the physical characteristics of an optical fiber
4.9 Describe how a macrobend changes the angle at which light hits the core-cladding boundary
4.10 Relate how light rays have to fall within a fiber's acceptance angle, measured by the numerical aperture (NA), in order to be guided into the core
4.11 Identify the cone of acceptance as used in optical fiber
4.12 List the ANSI/TIA-568-C.3, ISO/IEC 11801, and ITU Series G minimum overfilled modal bandwidth-length product (MHz·km) limitations for common multimode optical fiber and cable types

5.0 SAFETY

5.1 Explain how to safely handle and dispose of fiber optic cable
  5.1.1 Explain potential electrical hazards in a fiber optic environment
  5.1.2 Describe typical work place hazards in the fiber optic environment
5.2 Explain the three lines of defense to help you get through the day safely including:
  5.2.1 Engineering controls
  5.2.2 Personal protective equipment
  5.2.3 Good work habits
5.3 List the safety classifications of fiber optic light sources as described by the FDA, ANSI, OSHA, and IEC to prevent injuries from laser radiation
5.4 Explain the potential chemical hazards in the fiber optic environment and the purpose of the material safety data sheet (MSDS)

6.0 FIBER OPTIC CABLES

6.1 Draw a cross-section of a fiber optic cable and explain the purposes of each segment
6.2 Distinguish between the two buffer type cables:
  6.2.1 Loose buffer (stranded vs. central tube)
  6.2.2 Tight buffer (distribution vs. breakout)
6.3 Identify the different types of strength members used to withstand tensile forces in an optical fiber cable
6.4 Compare the choice of jacket materials and how they play a crucial role in determining characteristics of a cable
6.5 Describe the following cable types:
  6.5.1 Simplex cordage

- 6.5.2 Duplex cordage
- 6.5.3 Distribution cable
- 6.5.4 Breakout cable
- 6.5.5 Armored cable
- 6.5.6 Messenger cable
- 6.5.7 Ribbon cable
- 6.5.8 Submarine cable
- 6.5.9 Aerospace cable
- 6.5.10 Stranded Loose Tube cable
- 6.5.11 Central Loose Tube cable

6.6 Explain what hybrid cables are and where they are ordinarily used in fiber optics in accordance with ANSI/TIA-568-C.1

6.7 Describe a composite cable, as defined by National Electrical Code (NEC®) Article 770.2

6.8 Distinguish the difference between a fanout kit (sometimes called a furcation kit) and a breakout kit

6.9 Explain how fibers can be blown through microducts instead of installing cables underground or in structures.

6.10 List the National Electrical Code (NEC®) optical fiber cable categories including:

- 6.10.1 Abandoned optical fiber cable
- 6.10.2 Nonconductive optical fiber cable
- 6.10.3 Composite optical fiber cable
- 6.10.4 Conductive optical fiber cable

6.11 Describe the NEC® listing requirements for:

- 6.11.1 Optical fiber cables
- 6.11.2 Optical fiber raceways

6.12 Explain where the TIA-598-C color code is used and how the colors are used to identify individual cables

6.13 Describe TIA-598-C premises cable jacket colors

6.14 Explain how cable markings are used to determine the length of a cable

7.0 TYPES OF SPLICING

7.1 Mechanical Splicing

- 7.1.1 Explain the extrinsic factors that affect splice performance
- 7.1.2 Differentiate between the attributes and tolerances for different single-mode optical fibers as defined in ITU G series G.652, G.655, G.657. ANSI/TIA-568, ANSI/TIA-758 and Telcordia standards
- 7.1.3 Summarize the correct fiber preparation scoring method using a cleaver
- 7.1.4 Discuss the mechanical splice assembly process
- 7.1.5 Explain performance characteristics of index matching gel used inside the mechanical splice
- 7.1.6 Perform ANSI/TIA-568-C.0 (Annex E.8.3) Optical Time Domain Reflectometer (OTDR) insertion loss procedures for a reflective event mechanical splice

7.2 Fusion Splicing

- 7.2.1 Describe the advantages of fusion splicing over mechanical splicing
- 7.2.2 Summarize the correct fiber preparation scoring method using a cleaver
- 7.2.3 Discuss the fusion splice assembly process and splice protection
- 7.2.4 Explain the use of the Splice Closure
- 7.2.5 Explain ANSI/TIA-568-C.0 (Annex E.8.3) Optical Time Domain Reflectometer (OTDR) insertion loss procedures for a non-reflective event fusion splice

8.0 CONNECTORS

- 8.1 Identify the wide variety of fiber optic connector types
- 8.2 Describe the three most common approaches to align the fibers including:
  - 8.2.1 Ferrule based connector
  - 8.2.2 V-groove assemblies for multiple fibers
  - 8.2.3 Expanded-Beam connector
- 8.3 Describe the ANSI/TIA-568-C.3 section 5.2.2.4 two types of array adapters
  - 8.3.1 Type-A MPO and MTP® adapters shall mate two array connectors with connector keys key-up to key-down
  - 8.3.2 Type-B MPO and MTP® adapters shall mate two array connectors with connector keys key-up to key-up
- 8.4 Describe ferrule materials used with fiber optics connectors
- 8.5 Explain both the and extrinsic factors that affect connector performance
- 8.6 Define both physical contact (PC) and angled physical contact (APC) finish
  - 8.6.1 Explain how PC and APC finishes affect both insertion loss and back reflectance
- 8.7 Explain how physical contact depends on connector endface geometry to include the Telcordia GR-326 three key parameters for optimal fiber contact:
  - 8.7.1 Radius of curvature
  - 8.7.2 Apex offset
  - 8.7.3 Fiber undercut and protrusion
- 8.8 Describe how and where pigtails are used in fiber cabling
- 8.9 Summarize connector termination methods and tools
- 8.10 Compare the differences between field polishing, factory polishing, and no-epoxy/no-polish connector styles
- 8.11 Describe how to properly perform a connector endface cleaning and visual inspection in accordance with ANSI/TIA-455-57B Preparation and Examination of Optical Fiber Endface for Testing Purposes
- 8.12 Explain how to guarantee insertion loss and return loss performance in accordance with the IEC 61300-3-35 the global common set of requirements for fiber optic connector endface quality
- 8.13 Identify both multimode and single-mode connector strain relief, connector plug body, and adapter housing following ANSI/TIA-568-C.3 section 5.2.3

9.0 SOURCES

- 9.1 Describe the two primary types of light sources including the light emitting diode (LED) and semiconductor laser (also called a laser diode)
- 9.2 Explain the basic concept, operation and address launch conditions of a LED light source
- 9.3 Discuss the spontaneous emission process used by LEDs to generate light
- 9.4 Outline the differences between the surface-emitting and the edge-emitting LEDs, which are commonly used in fiber optic communication systems
- 9.5 Explain the basic concept and operation of a laser diode light source
- 9.6 Discuss the stimulated emission process used by lasers to generate light
- 9.7 List the differences between the Fabry-Perot (FP), distributed feedback (DFB), and vertical-cavity surface-emitting laser (VCSEL), which are commonly used in fiber optic communication systems
- 9.8 Recall the typical operational wavelengths for communication systems
- 9.9 Compare the performance characteristics of the LED and laser light sources to include:
  - 9.9.1 Output pattern (sometimes referred to as spot size)
  - 9.9.2 Source spectral width
  - 9.9.3 Source output power
  - 9.9.4 Source modulation speed

9.10 Compare the transmitter performance characteristics of the LED and laser light sources on a typical specification sheet to include:
- 9.10.1 Operating conditions
- 9.10.2 Electrical characteristics
- 9.10.3 Optical characteristics
- 9.10.4 Institute of Electrical and Electronics Engineers (IEEE) 802.3 Ethernet applications

9.11 Identify standards and federal regulations that classify the light sources used in fiber optic transmitters

9.12 Explain the differences between an overfilled launch condition and a restricted mode launch (RML)

10.0 DETECTORS AND RECEIVERS

10.1 Explain the basic concept and operation of a PN photodiode when used in an electrical circuit

10.2 Explain the use for PIN photodiodes and theory of operation

10.3 Describe the action of an avalanche photodiode (APD)

10.4 Compare the factors in photodiode performance characteristics including:
- 10.4.1 Responsivity
- 10.4.2 Quantum efficiency
- 10.4.3 Switching speed

10.5 Discuss how fiber optic receivers are typically packaged with the transmitter and how together, the receiver and transmitter form a transceiver

10.6 Examine a block diagram of a typical receiver that is divided into three subassemblies:
- 10.6.1 Electrical subassembly
- 10.6.2 Optical subassembly
- 10.6.3 Receptacle

10.7 Describe the two key characteristics of a fiber optic receiver:
- 10.7.1 Dynamic Range
- 10.7.2 Wavelength

10.8 Describe the performance characteristics of a fiber optic receiver to include:
- 10.8.1 Recommended operating conditions
- 10.8.2 Electrical characteristics
- 10.8.3 Optical characteristics
- 10.8.4 IEEE 802.3 Ethernet applications

11.0 PASSIVE COMPONENTS AND MULTIPLEXERS

11.1 Discuss the different passive devices and the common parameters of each device:
- 11.1.1 Optical fiber and connector types
- 11.1.2 Center wavelength and bandwidth
- 11.1.3 Insertion loss
- 11.1.4 Excess loss
- 11.1.5 Polarization-dependent loss (PDL)
- 11.1.6 Return loss
- 11.1.7 Crosstalk in an optical device
- 11.1.8 Uniformity
- 11.1.9 Power handling and operating temperature

11.2 Explain how optical splitters work and describe the technologies used to include:
- 11.2.1 Tee splitter
- 11.2.2 Reflective and transmissive star splitters

11.3 Compare the different types of optical switches that open or close an optical circuit

11.4 Explain that an optical attenuator is a passive device used to reduce an optical signal’s power level

11.5 Explain that an optical isolator comprises elements that only permit the forward transmission of light

- 11.6 Explain how wavelength division multiplexing (WDM) combines different optical wavelengths from two or more optical fibers into just one optical fiber
- 11.7 Explain the difference between coarse wavelength division multiplexing (CWDM) and dense wavelength division multiplexing (DWDM)
- 11.8 Compare the three different techniques with which to passively amplify an optical signal:
  - 11.8.1 Erbium doped fiber amplifiers
  - 11.8.2 Semiconductor optical amplifiers
  - 11.8.3 Raman fiber amplifiers
- 11.9 Point out that an optical filter is a device that selectively permits transmission or blocks a range of wavelengths

12.0 PASSIVE OPTICAL NETWORKS (PON)

- 12.1 Define the passive and active individual optical network categories
- 12.2 Explain that the fiber to the X (FTTX) is used to describe any optical fiber network that replaces all or part of a copper network
- 12.3 Discuss the major outside plant components for a fiber to the X (FTTX) passive optical network (PON) following both the Telcordia GR-20 and GR-765 standard and International Telecommunications Union (ITU) G.983 Broadband Optical Access Systems Based on Passive Optical Networks standard
- 12.4 Compare the fundamentals of a passive optical network (PON) including fiber-to-the-home (FTTH), fiber-to-the-building (FTTB), fiber-to-the-curb (FTTC), and fiber-to-the-node (FTTN)

13.0 CABLE INSTALLATION AND HARDWARE

- 13.1 Define the physical and tensile strength requirements for optical fiber cables recognized in ANSI/TIA-568-C.3, section 4.3 to include:
  - 13.1.1 Inside plant cables
  - 13.1.2 Indoor-outdoor cables
  - 13.1.3 Outside plant cable
  - 13.1.4 Drop cables
- 13.2 Compare the bend radius and pull strength tensile ratings of the four common optical fiber cables recognized in ANSI/TIA-568-C.3, section 4.3
- 13.3 Identify some the hardware commonly used in fiber optic installation to include:
  - 13.3.1 Pulling grips, pulling tape and pulling eyes
  - 13.3.2 Pull boxes
  - 13.3.3 Splice enclosures
  - 13.3.4 Patch panels
- 13.4 Compare the variety of installation methods used to install a fiber optic cable such as:
  - 13.4.1 Tray and duct
  - 13.4.2 Conduit
  - 13.4.3 Direct burial
  - 13.4.4 Aerial
  - 13.4.5 Blown optical fiber (BOF)
- 13.5 Describe the National Electrical Code (NEC®) Article 770 and Article 250 requirements on fiber optic cables and their installation within buildings
  - 13.5.1 Fire resistance
  - 13.5.2 Grounding
- 13.6 Discuss the documentation and labeling requirements in order to follow a consistent and easily readable format as described in ANSI/TIA-606-B Administration Standard for the Commercial Telecommunications Infrastructure
- 13.7 Describe hardware management

14.0 FIBER OPTIC SYSTEM CONSIDERATIONS

- 14.1 List the considerations for a basic fiber optic system design
- 14.2 Identify the seven different performance areas within a system and evaluate performance of optical fiber to copper in the areas of:
  - 14.2.1 Bandwidth
  - 14.2.2 Attenuation
  - 14.2.3 Electromagnetic immunity
  - 14.2.4 Size
  - 14.2.5 Weight
  - 14.2.6 Security
  - 14.2.7 Safety
- 14.3 Describe the performance of a multimode fiber optic link using the following sections of the ANSI/TIA-568-C.3 Optical Cabling Components Standard
  - 14.3.1 Section 4.2 cable transmission performance
  - 14.3.2 Section 5.3 optical fiber splice
  - 14.3.3 Annex A (Normative) optical fiber connector performance specifications
- 14.4 Explain how to prepare a multimode optical link power budget as defined in IEEE 802.3 definition 1.4.217
- 14.5 Calculate a multimode optical link power budget
- 14.6 Analyze the performance of a single-mode fiber optic link using the following sections of the ANSI/TIA-568-C.3 Optical Cabling Components Standard, ANSI/TIA-758 Customer–Owned Outside Plant Telecommunications Cabling Standard, and Telcordia GR-326 Core Generic Requirements for Single-mode Optical Connectors and Jumper Assemblies
  - 14.6.1 ANSI/TIA-568-C.3 Section 4.2 cable transmission performance
  - 14.6.2 ANSI/TIA-758 Section 6.3.4.1.2 attenuation
  - 14.6.3 ANSI/TIA-568-C.3 Annex A (Normative) optical fiber connector performance specifications
- 14.7 Explain how to prepare a single-mode optical link power budget as defined in IEEE 802.3 definition 1.4.217
- 14.8 Calculate a single-mode optical link power budget

15.0 TEST EQUIPMENT AND LINK/CABLE TESTING

- 15.1 Compare and contrast the functional use of the following pieces of test equipment:
  - 15.1.1 Continuity tester
  - 15.1.2 Visual fault locator (VFL)
  - 15.1.3 Fiber identifier
  - 15.1.4 Optical return loss test set (ORL)
  - 15.1.5 Light source (FOS) and power meter (FOM)
  - 15.1.6 Optical loss test set (OLTS)
- 15.2 Explain the proper use of the following pieces of test equipment:
  - 15.2.1 Continuity tester
  - 15.2.2 Visual fault locator (VFL)
  - 15.2.3 Fiber identifier
  - 15.2.4 Optical return loss test set (ORL)
  - 15.2.5 Light source (FOS) and power meter (FOM)
  - 15.2.6 Optical loss test set (OLTS)
- 15.3 Compare the difference between an optical fiber patch cord and measurement quality test jumpers (MQJ)
- 15.4 Describe the use of a mandrel wrap or mode filter on both a multimode and single-mode source measurement quality reference jumper

15.5 Explain the ANSI/TIA-526-14-B Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant procedures to include:
- 15.5.1 Method A: Two Jumper Reference
- 15.5.2 Method B: One Jumper Reference
- 15.5.3 Method C: Three Jumper Reference
- 15.5.4 Encircled Flux launch conditions

15.6 Describe the proper setup and cable preparation for an Optical Time Domain Reflectometer (OTDR) measurement to include:
- 15.6.1 Measure fiber length
- 15.6.2 Evaluate connectors and splices
- 15.6.3 Locate faults
- 15.6.4 Rayleigh scattering
- 15.6.5 Fresnel reflections
- 15.6.6 Pulse suppressor (launch fiber)
- 15.6.7 Deadzone cabling
- 15.6.8 Access jumpers

16.0 TROUBLESHOOTING AND RESTORATION (Tier 1 and 2 Testing)

16.1 Perform Fiber Optic Source (FOS) and Fiber Optic Meter (FOM) fiber optic link testing
16.2 Perform Fiber Optic Source (FOS) and Fiber Optic Meter (FOM) patch cable testing
16.3 Perform Optical Time Domain Reflectometer (OTDR) unit length testing
16.4 Perform Optical Time Domain Reflectometer (OTDR) connector and splice evaluation
16.5 Perform Optical Time Domain Reflectometer (OTDR) fault location
16.6 Demonstrate and prepare acceptance testing documentation

End of Fiber Optics Technician Competencies Listing:
(16 Major Knowledge Categories)

Find an ETA approved school and approved test site: **http://www.eta-i.org/test_sites.html**

A successful Fiber Optic Technician FOT may also qualify for the Journeyman option Certified Electronics Technician (CET) by holding the Associate CET certification.

Suggested Study Materials and Resources for ETA® Fiber Optics Technician Certification:

Fiber Optic Design for Multimode and Single-mode Optical Local Area Networks; Corning Cable Systems LLC; FSD400-R7.M5; 2009. http://catalog2.corning.com/CorningCableSystems/en-US/catalog/DocumentLibrary.aspx

Cabling: The Complete Guide to Copper and Fiber-Optic Networking, 5E; Andrew Oliviero, Bill Woodward; ISBN 978-1-118-80732-3; Sybex, Inc; March 2014; paperback; 1284 ppg**.** —Available through ETA at 800-288-3824, www.eta-i.org

Troubleshooting Optical Fiber Networks: Understanding and Using Optical Time-Domain Reflectometers, 2E; Duwayne Anderson, Larry Johnson, Florian Bell; ISBN 978-0120586615; Elsevier Academic Press; May 2004; hardcover; 437 ppg; 800-545-2522

Technology Series Videos and CDs; The Light Brigade, 800-451-7128, www.lightbrigade.com

Technicians Guide to Fiber Optics, 4E; Donald J. Sterling; ISBN 1-4018-1270-8; Delmar Learning; Dec 2003; hardcover; 384 ppg; Available through ETA 800-288-3824, www.eta-i.org

Fiber Optic Installer's Field Manual; Bob Chomycz; ISBN 0-07-135604-5; McGraw-Hill; Jun 2000; softcover; 368 ppg; —Available through ETA at 800-288-3824, www.eta-i.org

Fiber Optic Installer and Technician Guide; Bill Woodward, Emile Husson; ISBN 978-0782143904; Sybex, Inc; July 2005; hardcover; 496 ppg; Available through ETA 800-288-3824, www.eta-i.org

Understanding Fiber Optics, 5E; Jeff Hecht; ISBN: 978-0131174290; Prentice-Hall; Apr 2005; hardcover; 800 ppg

Introduction to Fiber Optics, 3E; John Crisp, Barry Elliott; ISBN 978-0750667562; Newnes; Dec 2005; paperback; 245 ppg

Fiber Optic Theory & Applications; Jeffrey Dominique; 1993; FNT Publ.; paperback www.f-n-t.com

Guide Design and Implement Local and Wide Area Networks, 3E; Michael Palmer and Bruce Sinclair, ISBN 978-0619216115; Course Technology; June 2012; paperback; 250 ppg

Optical Networking Crash Course; Steven Shepard; ISBN 007-1372083; McGraw-Hill Co.; July 2008; paperback; 288 ppg

Optical Networking: A Beginner's Guide; Robert C. Elsenpeter; ISBN 978-0072193985; McGraw-Hill Co.; Dec 2001; paperback; 544 ppg

Optical Networking & WDM; Walter J. Goralski; ISBN 978-0072130782; McGraw-Hill Co.; Jan 2001; paperback; 556 ppg

Designers Guide to Fiber Optics; AMP Corp., Harrisburg, PA 17105; ASIN B000IU64O; 1982; paperback; 209 ppg

National Electrical Code, 2017; National Fire Protection Assn., Sept., 2013; www.nfpa.org

Also contact ETA at www.eta-i,org or 1-800-288-3824 for more information, numerous links, locations for training sites, additional white papers, articles and the latest Fiber updates.

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ETA certification programs are accredited through the ICAC, complying with the ISO/IEC 17024 standard.