# Telecommunications and Fiber Optics Standards and Skills

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## Health & Safety Standards

### Standard 1: Safety and Health in a Telecommunications and Fiber Optics Environment

Students will demonstrate an understanding of safety practices relevant to the Telecommunications and Fiber Optics environment, ensuring compliance with OSHA requirements and promoting a safe, ergonomic workplace.

* Aligned Industry Recognized Credentials: OSHA10 – General Industry

#### Skills:

1. Identify, describe, and demonstrate the effective use of Safety Data Sheets (SDS) to meet documentation requirements.
2. Locate emergency equipment, first aid kit, and emergency action and response plan, including labels and signage that follow OSHA Hazard Communication Program (HAZCOM).
3. Apply best practices for managing hazardous materials in telecommunications work, including proper labeling, storage, and disposal in accordance with HAZCOM and environmental regulations.
4. Demonstrate safe dress and use of relevant safety gear, personal protective equipment (PPE), and jobsite ergonomics, e.g., safety equipment, gloves, proper footwear, knee pads, earplugs, eye protection, and breathing apparatus.
5. Demonstrate safe body mechanics, including appropriate lifting techniques and ergonomics aimed at minimizing injury.
6. Implement proper grounding techniques and apply safety protocols to effectively mitigate electrical hazards.
7. Apply Lockout/Tagout (LOTO) procedures to ensure equipment is properly de-energized before maintenance, repair, or inspection activities.
8. Understand the level of electricity (shock) considered lethal to humans.
9. Understand and apply relevant sections of the National Electrical Code (NEC) that pertain to telecommunications wiring and fiber optic installations, ensuring compliance with safety standards.
10. Demonstrate proper handling and disposal of fiber optic materials, including shards and cables, to prevent injury and environmental harm.
11. Identify and implement safety precautions when working with laser-based fiber optic equipment to avoid eye injuries and other hazards.
12. Identify and apply safety protocols when working in confined spaces, ensuring adequate ventilation and compliance with OSHA confined space regulations.
13. Understand OSHA body restraint rules and identify the hazards associated with use of ladders and working at heights.
14. Understand and apply appropriate fire protection regulations, local permit regulations, and state/federal regulations.

## Technical & Integrated Academic Standards

### Standard 2: Role of Telecommunications and Fiber Optics Professionals in Society

Students will demonstrate a comprehensive understanding of how electronic communication technology has historically propelled advancements in communication, learning, and education, while also exploring its modern applications in today's digital landscape.

* Aligned Industry Recognized Credentials: CFOT – Certifed Fiber Optic Technician, CPCT – Certified Premises Cabling Technician

#### Skills:

1. Understand the historical significance of Telecommunications and Fiber Optics in the development and progression of advanced civilizations.
2. Evaluate the significance of Telecommunications and Fiber Optics in relation to human communications and free speech.
3. Analyze the historical timeline and development of fiber optics, identifying key milestones, technological advancements, and their impact on modern communication systems.
4. Apply Telecommunications Industry Association (TIA), Electronics Industries Alliance (EIA), and American National Standards Institute (ANSI) standards to the work of a systems technician.

### Standard 3: Tools and Instrumentation

Students will apply and demonstrate appropriate selection, safe use, and maintenance of equipment and tools required for installation and maintenance of telecommunication systems and fiber optic projects.

* Aligned Industry Recognized Credentials: CFOT, CPCT

#### Skills:

1. Apply the proper techniques for using gofer poles, drills, bits, scissors, and face masks during installation and maintenance when handling fiber optics to prevent injury from glass shards or chemicals.
2. Explain and demonstrate the importance of grounding in telecommunications systems and the proper use of grounding tools to ensure safety and signal quality.
3. Demonstrate the effective use of wire strippers, crimpers, punch-down tools, and fish tapes for various cabling tasks.
4. Demonstrate the proper use of a cable jacket stripper for removing the outer sheath of fiber optic cables without damaging the internal fibers.
5. Demonstrate the use of a fiber optic cleaver to precisely cut optical fibers, ensuring clean and smooth edges for effective splicing.
6. Demonstrate the use of a fusion splicer for joining optical fibers, including preparing the fiber, aligning, splicing, and testing the splice for signal loss.
7. Demonstrate the use of a toner and light meter/source for identifying and testing cables and explain their application in accurate signal tracing and verification.
8. Demonstrate the use of a VOM meter (Volt-Ohm-Milliammeter), including each function, and explain how to interpret measurements for accurate troubleshooting and diagnostics.
9. Demonstrate the use of a fiber optic microscope to inspect the end faces of fiber connectors for cleanliness and damage.
10. Demonstrate the proper installation of an F connector using a compression tool and fittings, ensuring secure and reliable connections.
11. Demonstrate the use of a cable tester to verify the integrity and performance of both copper and fiber optic cables, ensuring compliance with industry standards.
12. Demonstrate the use of an OTDR (Optical Time-Domain Reflectometer) to test and analyze the integrity of fiber optic cables, including interpreting the results to identify faults, splices, and bends.
13. Explain the necessity of wire-pull lubricant and demonstrate its application to facilitate smooth cable installation and reduce potential damage.
14. Demonstrate the use of cable markers to identify cables and apply methods for identifying wires that lack markers, ensuring that cabling systems remain organized and easily traceable.
15. Demonstrate the use of cable management tools such as cable ties, Velcro straps, and cable organizers to ensure a clean and efficient installation.

### Standard 4: Low Voltage Wiring

Students will apply technical knowledge and evaluation skills to ensure compliance with blueprint specifications and industry standards for low voltage and audio wiring systems.

* Aligned Industry Recognized Credentials: CFOT, CPCT

#### Skills:

1. Apply blueprint specifications to ensure fidelity to project objectives.
2. Understand American Wire Gauge (AWG) and explain AWG wire size standards.
3. Analyze and interpret government regulations to determine the necessary permits required for the installation or servicing of low voltage wiring, ensuring full compliance with local, state, and federal requirements.
4. Understand low voltage lighting, its usage, and precautions.
5. Evaluate current audio signal and speaker cabling and wiring and the reasons for choice of wire.
6. Understand CAT 5e and 6 UTP cables and preferred usages.
7. Evaluate control and sensor wiring used for home automation and manual operation.
8. Identify and evaluate emerging trends and technologies in low voltage systems, including advancements in smart home automation, and assess their potential impact on current and future wiring practices.

### Standard 5: Cabling and Connectors

Students will be able to understand and evaluate various materials, standard techniques, and concepts related to network cable installation.

* Aligned Industry Recognized Credentials: CFOT, CPCT

#### Skills:

1. Compare the usage of copper coaxial cables and plastic fiber optic cables in residential applications and justify the selection based on project requirements.
2. Demonstrate the use of 66 and 110 block panels in telecom distribution and interface centers and evaluate their effectiveness in network configurations.
3. Interpret and assess the standards for patch cables, including maximum length, and evaluate the impact on network performance.
4. Differentiate between workstation cables and other cabling types and explain their specific functions in network setups.
5. Compare and contrast backbone/distribution cabling with link, workstation, and patch cables, and justify their selection in network designs.
6. Evaluate composite and hybrid cables' structure and function and assess their performance in various networking scenarios.
7. Demonstrate the proper use of cable prepping tools, execute the preparation of cable ends, and install connectors with precision.
8. Identify and analyze signal losses in cables, match impedance, and convert dB levels to microvolt levels with accuracy.
9. Prepare and install F coaxial cable fittings and resolve impedance issues to ensure signal integrity.
10. Install UTP, Cat 5e, and 6 connectors and evaluate their performance against network standards.
11. Analyze ground loops in electrical circuits and propose methods to prevent or mitigate their impact.
12. Compare different network topologies, e.g., ad hoc and infrastructure, evaluate their suitability, and design network layouts accordingly.
13. Implement effective cable management techniques to organize and secure cabling, ensuring longevity and accessibility.
14. Troubleshoot common issues with cabling and connectors and apply solutions to maintain optimal network performance.
15. Apply industry standards and regulations for cabling installations and ensure compliance throughout the installation process.
16. Test and validate cable installations using appropriate tools and document configurations and test results for future reference.
17. Evaluate the impact of environmental factors on cable performance, e.g., extreme temperatures, humidity, electromagnetic interference (EMI), etc., and implement strategies to mitigate these effects.

### Standard 6: Pre-Wiring

Students will be able to analyze and create the design and rough-in layout process.

* Aligned Industry Recognized Credentials: CFOT, CPCT

#### Skills:

1. Describe the task of roughing-in cabling in new structures, installing wall and distribution boxes, conduits, speaker-in-wall units, CCTV mounts, etc.
2. Explain the purpose and usage of biscuit jacks/surface mount boxes.
3. Interpret the role of wall plates in network setups, determine optimal locations for their installation, and justify placement decisions based on accessibility and functionality.
4. Assess the purposes and optimal placement of J-hooks and cable trays and design an efficient cable management system that supports organizational and safety standards.
5. Analyze the impact of inductive signal interference on network performance, formulate strategies to mitigate its effects, and apply correct separation distances for cabling to ensure signal integrity.
6. Compare the advantages and disadvantages of stranded versus solid wiring, justify the selection of either based on specific installation requirements and performance needs.
7. Describe detriments in exceeding TIA/EIA tensile strength/bend radius.
8. Design and apply a systematic wire labeling approach to ensure clear identification and efficient troubleshooting.
9. Explain and apply the methods used to accurately estimate cable requirements for individual applications.
10. Analyze UTP untwist precautions and evaluate NEXT/FEXT testing issues, develop solutions to minimize crosstalk, and ensure optimal performance.
11. Identify common problems encountered in coaxial cable installation or repair.
12. Describe the use of surface-mount channeling, design its application for specific installations, and implement channeling techniques to support cable organization and aesthetics.

### Standard 7: Fundamentals of Electricity and Electronics

Students will demonstrate a comprehensive understanding of electricity and electronic circuits, applying principles of electrical theory, circuit design, and troubleshooting to analyze, construct, and test various electronic systems effectively.

* Aligned Industry Recognized Credentials: CFOT, CPCT

#### Skills:

1. Apply Ohm’s and Watt’s Laws to perform electrical calculations, including solving multi-step problems related to electrical circuits.
2. Evaluate the processes of electric power generation and distribution and assess the quality of services provided to residential areas.
3. Describe wire size choices and distribution for home electrical circuitry.
4. Compare fuse and circuit breaker boxes and describe the components and metering.
5. Differentiate between AC and DC voltages and currents and assess the effects of these differences on various electronic systems and applications.
6. Explain the principles of electric circuit grounding and evaluate the National Electrical Code (NEC) rules for residential grounding, including the potential consequences of non-compliance.
7. Describe the hazards associated with lightning and analyze the effectiveness of lightning arrestors and ground blocks in electronic applications.
8. Compare the frequency ranges of AC power, voice, TV, radio, and data transmissions, and interpret their significance in electronic communication systems.
9. Identify sources of electrical interference in circuits and apply methods to reduce or eliminate these interferences in various electronic systems.
10. Identify and explain the function of various passive components found in DC and AC circuits.
11. Analyze and calculate DC and AC passive circuit parameters using applicable formulas.
12. Demonstrate constructing and the testing of proper DC and AC passive circuit functionality.
13. Describe the principles of electromagnetic compatibility and analyze the impact of electromagnetic interference (EMI) on electronic systems.
14. Apply techniques to design circuits that minimize EMI and ensure compliance with EMC standards.
15. Identify and explain different types of power supplies, including linear and switching power supplies.
16. Analyze the importance of voltage regulation in electronic circuits and design circuits that incorporate voltage regulators.
17. Identify and explain the function of energy storage devices, such as capacitors, batteries, and supercapacitors in electronic circuits.
18. Compare the characteristics and applications of different types of energy storage devices.
19. Identify and explain the function of discrete and integrated semiconductor devices and circuits.
20. Analyze and calculate DC and AC circuit parameters of discrete and integrated semiconductor circuits using applicable formulas.
21. Explain the basics of signal processing, including analog and digital signal processing.
22. Analyze the role of filters, amplifiers, and converters in signal processing applications.
23. Construct and demonstrate the testing of discrete and integrated semiconductor circuits, validating their functionality and identifying potential areas for improvement.
24. Identify and explain the function of logic gates and combinational and sequential logic circuits.
25. Analyze and calculate DC and AC circuit parameters of logic gates and combinational and sequential logic circuits using applicable formulas.
26. Construct and test logic gates and combinational and sequential logic circuits, demonstrating proper functionality and troubleshooting any issues encountered during testing.
27. Identify and explain the role of microcontrollers and embedded systems in modern electronics.
28. Design and program simple microcontroller-based systems to perform specific tasks.
29. Diagnose and repair defective components in electronic circuits, using advanced troubleshooting techniques and justifying the methods chosen.
30. Set up and utilize a variety of electronic/test equipment to analyze and validate the performance of electronic equipment and systems, ensuring compliance with industry standards.
31. Read, interpret, and evaluate flow, block, and schematic diagrams to synthesize solutions for complex electronic system designs.
32. Determine and evaluate the factors that affect thermal management of various electronic components and devices.

### Standard 8: Fundamentals of Telephony

Students will be able to understand, analyze, and evaluate the fundamentals of telephone systems, including basic wiring, analog and digital systems, and modern VoIP and cellular technologies.

* Aligned Industry Recognized Credentials: CFOT, CPCT

#### Skills:

1. Diagram and interpret a basic telephone circuit, identifying each component's role and predicting circuit behavior under various conditions.
2. Define and explain the concept of Tip & Ring, demonstrate the wiring conventions of the Plain Old Telephone Service (POTS), and evaluate the expected voltages on telephone plugs to troubleshoot potential issues.
3. Identify and compare the conventional colors of Unshielded Twisted Pair (UTP) wires used in 2/4/8 wire connections.
4. Demonstrate the use of type 66/110 punchdown blocks, analyzing their purpose in telecommunications infrastructure.
5. Compare and contrast analog and digital phone systems, assessing their advantages, disadvantages, and their applicability in various environments, e.g., residential and commercial.
6. Set up a basic VoIP system and explain key security practices, such as encryption and firewall rules, to ensure secure communication.
7. Analyze the key differences between internet-cable TV-wireless systems and B-VoIP, assessing their impact on communication quality and reliability.
8. Evaluate the main blocks that make up a Private Branch Exchange (PBX) system.
9. Analyze the concept of a cellular system, explaining the makeup of a cell and evaluating how these elements contribute to the efficiency and coverage of cellular networks.
10. Assess how handoffs and roaming work in cellular systems, identifying potential challenges and proposing solutions to enhance connectivity during movement.
11. Explain the terms “drop out” and “dead zones,” analyzing their causes and proposing strategies to mitigate these issues in different environments.
12. Diagnose common issues in telephony systems, e.g., dropped calls, poor voice quality, and apply systematic troubleshooting techniques to resolve them.
13. Evaluate the security risks associated with VoIP systems and design basic security protocols to protect against unauthorized access.
14. Explain the importance of adhering to telecommunications standards and regulations and analyze their impact on system performance and legal compliance.
15. Analyze the potential impact of emerging technologies, e.g., 5G and IoT, on telephony systems and examine ways to integrate these advancements into existing infrastructure.

### Standard 9: Fundamentals and Applications of Fiber Optics

Students will be able to understand and evaluate theories and applications of fiber optic cabling.

* Aligned Industry Recognized Credentials: CFOT, CPCT

#### Skills:

1. Explain how light is used to transfer information in fiber optic communications systems.
2. Differentiate between types of optical fibers (SI MM, GI MM, SM) and their specific applications.
3. Identify and select fiber optic cables with appropriate fire ratings for safe indoor installations.
4. Evaluate basic fiber specifications, including attenuation and dispersion, and their effects on transmission performance.
5. Justify the use of specific wavelengths in fiber optic applications and assess how these wavelength choices impact system performance and efficiency.
6. Interpret and apply the concept of “total internal reflection” within the context of fiber optic cable.
7. Compare and contrast different light sources used in fiber optic systems (LED, Laser FP, DFB, VCSEL) and their impact on performance.
8. Describe the role and operation of different detectors (photodiode, APD; Si, Ge, InGaAs) in a fiber optic system.
9. Analyze factors that determine the quality of data transmission in a fiber optic datalink.
10. Identify and describe the functions of various components in an Optical Service Provider (OSP) system, including Internet, Telco, CATV, Utility, and Municipal systems.
11. Identify and describe the types of fiber optic cables and their applications (tight buffer, loose tube, specialty).
12. Explain relevant specifications for fiber optic cables, such as water blocking, pulling strength, and armoring, and their implications for application.
13. Choose the proper fiber optic cable for specific applications based on its features and requirements.
14. Compare and contrast plastic and glass fiber options, analyze the factors that influence material choice, and recommend appropriate materials based on specific application requirements.
15. Describe the uses and performance requirements of fiber optic termination and splicing processes, including loss, reflectance, and strength.
16. Demonstrate proficiency in mechanical and fusion splicing processes, including mass (ribbon) fusion, and the associated hardware.
17. Explain the different types of fiber optic connectors (ST, SC, LC, MTP) and the termination processes, including adhesive (epoxy, anaerobic, HotMelt), prepolished splice, and SOC.
18. Outline the procedures for using prefab systems and the associated hardware in fiber optic termination.
19. Assess communication system requirements to design an appropriate fiber optic cable plant.
20. Develop a detailed layout for fiber optic networks, including selecting suitable components and calculating loss budgets.
21. Document the design process and specifications for a fiber optic network.
22. Develop a comprehensive plan for a fiber optic system installation, including the basic steps and considerations based on system requirements and best practices.
23. Adhere to safety protocols during installation, including eye safety, tool safety, chemical safety, and disposal of materials.
24. Demonstrate knowledge of relevant codes, standards, and regulations in fiber optic installation.
25. Perform the installation of fiber optic systems and document the cable plant accurately.
26. Perform cable tracing and polarity testing, including connector inspection and cleaning.
27. Conduct testing and troubleshooting of cable and cable plants, including optical power and system testing.
28. Demonstrate fiber characterization techniques to evaluate fiber performance and quality.
29. Explain the operation of an Optical Time-Domain Reflectometer (OTDR), evaluate its use in diagnosing issues within fiber optic systems, and apply this knowledge to interpret OTDR data.
30. Design and conduct an optical continuity test, evaluate the test results, and recommend corrective actions to address any issues identified during testing.
31. Perform and analyze fiber cable loss testing using a calibrated light source and a power meter.
32. Analyze the environmental impact of fiber optic installations and propose solutions to mitigate any negative effects, such as proper disposal of waste materials and energy-efficient practices.

### Standard 10: Principles of Electronic Communication

Students will analyze and apply the principles of electronic communication to understand and optimize signal properties, power levels, and waveform characteristics.

* Aligned Industry Recognized Credentials: CFOT, CPCT

#### Skills:

1. Compare the properties of signals in both acoustic and electrical forms and apply this comparison to design effective communication systems.
2. Interpret the dimensions of signal frequency, wavelength, and phase, and evaluate their effects on communication quality and system performance.
3. Calculate relationships between time vs. frequency, phase vs. distance, and phase vs. time, and apply these calculations to optimize signal transmission and reception.
4. Analyze power gain and loss in dB units, calculate these values, and convert them to power.
5. Calculate reference power levels in dBm, convert these values to power, and evaluate their significance in the context of communication systems.
6. Identify and assess the signal-to-noise (S/N) ratio required for effective communication in telephone and audio systems.
7. Analyze fundamental and harmonic frequencies of electrical signals and evaluate their impact on signal quality and system performance.
8. Identify and explain the harmonic structure of common signal waveforms.
9. Specify and evaluate the common forms of waveform distortion applied to signals in electronic circuits.
10. Explain the acoustic and electrical properties of common input and output transducers and evaluate their suitability for various communication systems.
11. Explain and apply basic signal processing techniques, such as filtering, modulation, and demodulation, and evaluate their impact on communication quality.
12. Compare common communication protocols, e.g., TCP/IP, UDP, and analyze their role in electronic communication systems.
13. Analyze sources of interference and noise in electronic communication systems and develop methods to mitigate their effects on signal integrity.
14. Compare and contrast digital and analog communication methods and evaluate their advantages and limitations.
15. Apply error detection and correction techniques, such as parity checks and error-correcting codes, to ensure reliable communication.

### Standard 11: Fundamentals of Wireless Communication

Students will be able to understand and apply the fundamental concepts of wireless communication technologies.

* Aligned Industry Recognized Credentials: CFOT, CPCT

#### Skills:

1. Compare and evaluate various modulation schemes, including amplitude modulation (AM), frequency modulation (FM), and phase modulation (PM).
2. Analyze the functions of a transmitter, receiver, and channel in a basic wireless communication system.
3. Explain and evaluate the purpose and properties of transmission lines, including their impact on signal integrity and system performance.
4. Calculate the length of a ½ wave dipole antenna for a given frequency and evaluate how this measurement affects antenna performance.
5. Compare ground waves, space waves, and sky waves and their effects on wireless communication over different distances and environments.
6. Identify and analyze the frequency components of AM, FM, and TV signals and their relevance to various wireless communication technologies.
7. Describe the major components of a communication satellite and ground stations, including their functions and how they contribute to satellite communication systems.
8. Identify the basic system requirements for digital data communications and design a digital communication system that meets these requirements.
9. Describe the nature and effects of transmission imperfections, such as signal attenuation and distortion.
10. Define and apply the terms aspect ratio, resolution, pixels, and triads in the context of HDTV, and analyze their impact on image quality and transmission efficiency.
11. Understand the regulatory standards and guidelines for wireless communication, including frequency allocation and compliance with communication regulations.
12. Describe and compare various wireless communication technologies, e.g., Wi-Fi, Bluetooth, LTE, 5G, including their applications and performance characteristics.
13. Analyze signal propagation characteristics and factors affecting coverage, such as obstacles, interference, and environmental conditions.
14. Identify sources of interference and noise in wireless communication systems and apply methods to minimize their impact on signal quality.
15. Analyze security issues in wireless communication, including encryption and authentication methods to protect data integrity and privacy.

## Employability Standards

### Standard 12: Employability Skills

Students will understand and demonstrate the roles of professional communication, critical thinking, problem solving, professionalism, teamwork, and collaboration within the context of the Telecommunications and Fiber Optics industry.

#### Skills:

1. Demonstrate effective communication and positive people skills to provide exceptional customer service across various platforms, including face-to-face interactions, telephone conversations, written, and electronic correspondence.
2. Demonstrate the ability to analyze complex problems and develop effective solutions.
3. Demonstrate active listening skills by giving full attention to others, taking the time to understand their points, and asking appropriate questions to meet job expectations and production methods.
4. Demonstrate working effectively in teams to achieve common goals, coordinating with other professionals, such as engineers, contractors, and project managers.

## Entrepreneurship Standards

### Standard 13: Entrepreneurship

Students will be able to describe opportunities for entrepreneurship and be able to evaluate the value proposition of business ownership in the telecommunications and fiber optics field.

#### Skills:

1. Evaluate the licensing, regulatory, and tax implications of self-employment and business ownership in the telecommunication and fiber optics industry compared to W-2 employment.
2. Understand current job trends, skill requirements, and potential areas of growth within the modern telecommunications and fiber optics industry, including roles in communications infrastructure, maintenance and repair, and systems design.
3. Evaluate emerging trends and technologies in wireless communication, such as advancements in 5G and the Internet of Things (IoT) and assess their potential impact on future communication systems and business ownership.

## Digital Literacy Standards

### Standard 14: Digital Literacy

Students will demonstrate proficiency in using common software and information technology tools in the telecommunications and fiber optics field.

#### Skills:

1. Demonstrate proficiency in using specialized software for network design, simulation, and analysis in the telecommunications and fiber optics industry.
2. Analyze and interpret data related to signal strength, network performance, and troubleshooting issues using digital tools like Excel, SQL, or dedicated analysis platforms.
3. Apply cybersecurity principles and practices to protect sensitive data and communication networks from cyber threats.
4. Manage cloud-based services and platforms for storage, computing, and communication within telecommunication networks.
5. Integrate and manage Internet of Things (IoT) devices within telecommunication networks, ensuring efficient data handling and network performance.
6. Create, store, and share digital documentation, including project reports, equipment logs, compliance records, and budget tracking to ensure comprehensive and organized project management.
7. Learn and apply new digital tools, platforms, and technologies as they emerge in the telecommunications and fiber optics industry.