Chapter 1
Installation Foundations

Chapter 1 discusses the foundations of information transport systems (ITS) installation practices with emphasis on the essentials of transmission, safety, and professionalism. ITS installers will gain the knowledge of copper and optical fiber media factors and requirements, personal and work area protection guidelines, and best communication practices, among other related topics.

Table of Contents

SECTION 1: TRANSMISSION

Transmission Methods and Media 1-1
Introduction 1-1
Terminology 1-2
Power, Current, and Voltage 1-2
Average Power 1-3
Alternating Current (ac) and Direct Current (dc) 1-3
Electromagnetics 1-4
Frequency 1-5
Bandwidth 1-5
Signal 1-5
Digital Transmissions 1-6
Analog to Digital Conversion 1-7
Megahertz (MHz) and Megabit (Mb) 1-8
Decibel (dB) 1-8

Copper Cabling Media 1-9
Overview 1-9
American Wire Gauge (AWG) 1-9
Basis of the American Wire Gauge (AWG) Numbering System 1-9
Solid Conductor Diameters 1-9
Resistance 1-11
Inductance 1-12
Capacitance 1-13
Impedance 1-13
Characteristic Impedance 1-13
Insertion Loss (Attenuation) 1-14
Return Loss 1-14
Crosstalk 1-15
Near-End Crosstalk (NEXT) 1-15
Far-End Crosstalk (FEXT) 1-15
Alien Crosstalk (AXT) 1-17
Nominal Velocity of Propagation (NVP) 1-18
Propagation Delay 1-18

Delay Skew 1-18
Insulation 1-18
Pair Twist 1-19
Shielding 1-20
Coaxial Cables 1-22
Hardware 1-22

Optical Fiber Cable Media 1-23
Overview 1-23
Bandwidth 1-25
Dispersion 1-25
Modal Dispersion 1-25
Chromatic Dispersion 1-25
Differential Mode Delay (DMD) 1-26
Attenuation 1-27

SECTION 2: SAFETY

Common Safety Practices 1-29
Overview 1-29
Safety Awareness 1-29
First Aid 1-30
First Aid, CPR, and the Law 1-30
First Aid Kits 1-30
Emergency Rescue 1-31
Communication 1-32
Designating Work Areas 1-33
Tools and Equipment 1-34
Ladder Safety 1-35
Personnel Lifts 1-38

Personal Protective Equipment (PPE) 1-39
Overview 1-39
Headgear 1-39
Eye Protection 1-40
Breathing Protection 1-41
Lifting Belt 1-41
Protective Footwear 1-42
Gloves 1-42

Detection Badges/Exposure Monitors 1-42
High Visibility Vest or Jacket 1-43
Hearing Protection 1-43
Safety Harness 1-44
Clothing 1-45
Grooming 1-45

Hazardous Environments—Indoor 1-46

Overview 1-46
Electrical Hazards 1-46
Lightning Hazards 1-48
Access Floors 1-49
Catwalk Hazards 1-49
Crawl Space Hazards 1-50
Confined Spaces 1-51
Optical Fiber Hazards 1-52
Battery Hazards 1-53
Asbestos Hazards 1-53
Chemical Hazards 1-54
Other Hazardous Locations 1-55

Hazardous Environments—Outdoor 1-56

Outside Plant (OSP) 1-56

Safety Planning 1-56

Overview 1-56
Management Commitment and Employee Involvement 1-56
Work Site Analysis 1-57
Hazard Prevention and Control 1-57
Health and Safety Training 1-57

Example of a Job-Site Inspection Checklist 1-58

ITS Job-Site General Inspection 1-58

SECTION 3: PROFESSIONALISM

Professionalism 1-59

Overview 1-59
Technical Expertise 1-59
Project Objectives 1-59
Project Team Members 1-60
Team Member Responsibilities 1-60

Interpersonal Skills and Communication Requirements 1-61
Effective Communication Skills 1-61
Customer Relations 1-62
Customer Perception 1-63
Feedback and Follow-Through 1-64
Professional Appearance 1-65

References 1-66

Figures

Figure 1.1 Analog sine wave 1-4
Figure 1.2 Digital signal 1-6
Figure 1.3 Ohm's Law 1-12
Figure 1.4 Schematic of a transmission line 1-13
Figure 1.5 Crosstalk paths 1-16
Figure 1.6 Six-around-one alien crosstalk measurements configuration 1-17
Figure 1.7 Typical balanced twisted-pair cable 1-19
Figure 1.8 Shielding 1-21
Figure 1.9 Core profile—laser-certified optical fiber. 1-26
Figure 1.10 Designated work area 1-33
Figure 1.11 Extension ladder 1-36
Figure 1.12 Eye protection 1-40
Figure 1.13 Hearing protection 1-43
Figure 1.14 Communications perceptions 1-64

Tables

Table 1.1 Conductor size 1-10
Table 1.2 Optical fiber cable bandwidth performance parameters 1-24
Table 1.3 Optical fiber cable attenuation performance parameters 1-24
Table 1.4 Harness specifications 1-44
Table 1.5 Project communications 1-62

Transmission Methods and Media

Introduction

This section describes the terms, methods, and issues related to the movement (transmission) of information over various physical media. It also identifies the impact information transport system (ITS) cabling installation methods have on transmission.

In the context of this manual, transmission is the movement of information in the form of electrical or optical signals from one point to another through a transport medium. This section deals with the use of copper conductors and glass strands for the passing of signals in analog or digital form.

Three transmission methods are:

- Simplex, which transmits signals in one direction only. A public address system is a simple example of simplex transmission. The signal, or the speaker's voice, is carried to a number of loudspeakers. The listener has no path to respond.
- Half-duplex, which can transmit signals in either direction but in only one direction at a time. This type of transmission typically requires agreement between stations and involves a "push to talk" switch arrangement on voice circuits or a signaling protocol on data circuits.
- Full duplex, which can transmit signals in both directions at the same time. All modern telephone circuits are full duplex, allowing both parties to talk simultaneously.

The choice of a specific transport medium is influenced by economics and technical considerations, such as the:

- Physical diameter of the cable.
- Type of services to be provided (e.g., voice, data, and video).
- Topology and size of the network.
- Transmission path distance.
- Transmission performance characteristics of the cabling.

In balanced twisted-pair systems, when electromagnetic interference (EMI) conditions cannot be readily solved by shielded copper cabling or by increasing physical separation, optical fiber may be used. EMI and other types of electrical interference do not affect optical fiber cable, with the exception of situations where an extremely strong magnetic field is created (e.g., magnetic resonance imaging [MRI]).

Introduction, continued

All media have certain characteristics that limit performance. Media selection may be based on specific network requirements when such network requirements are known. Once the proper selection has been made, allowances for common degradation factors must be considered.

To ensure compliance with cabling standards for higher transmission performance, manufacturers of copper and optical fiber cable and connecting hardware initiated design changes in their products.

For balanced twisted-pair copper cabling, the assignment of a category or classification performance rating (e.g., category 3/class C, category 5e/class D, category 6/class E, category 6_A/class E_A, category 7/class F, and category 7_A/class F_A) provides a simple means to select cabling suitable for the limited requirements of a voice circuit or a cabling that meets the demanding requirements of a data circuit.

NOTE: Twisted-pair cable is called balanced because the physical construction of both conductors of a pair is the same. Coaxial cable is unbalanced because the two conductors have different constructions.

Terminology

This section defines the major terms associated with signal transmission. The objective is to show the impact that improper cabling installation can have on media transmission characteristics.

Power, Current, and Voltage

Power (P) measured in watts (W) is also known as real, true, or actual power. This type of power is a term that applies to the energy consumed by an electrical device (e.g., a motor, amplifier, or telephone transmitter). Power is derived from electrical pressure measured in volts (V) and electrical current measured in amperes (I)—no power is generated unless both are present. Using a water analogy, voltage may be thought of as the water pressure, while current represents the quantity of water delivered. Millions of volts without current flow will not provide any power and, therefore, will not energize a device to perform the desired function.

Apparent (peak) power is equal to the voltage (V) multiplied by the current (I) or $P = VI$. It is usually referenced in volt-amperes (VA). Apparent power is specified in alternating current (ac) circuits that have reactive components (i.e., inductors and capacitors).

Terminology, continued

Average Power

Peak power (P_P or P) is shown defined as watt (W) but it is actually V × current in amperes (I). Manufacturers of electronic devices usually show VA to signify apparent power. Peak power is a measure of electrical service consumption that a given device is designed to accept. It indicates the maximum power that is required for the device to operate under full load conditions. However, peak power is present only twice during a cycle. A better indication of power consumption is average power (P_A). Average power is the sustained power over 70 percent of the cycle and is shown in watts; it represents the usable portion of ac power.

$$P_A = 0.707 \times V \times I$$

EXAMPLE:

A device operating at maximum load under normal conditions uses 4.5 A at 120 V.

Peak Power	P	=	4.5 A × 120 V	=	540 VA
Average Power	P_A	=	0.707 × 4.5 × 120	=	382 W

The amount of current flow in a telecommunication circuit is usually very small compared with that of a commercial electrical power line.

Electronic equipment and uninterruptible power supplies (UPS) are generally rated in average power if shown as W and in peak power if shown as VA.

Alternating Current (ac) and Direct Current (dc)

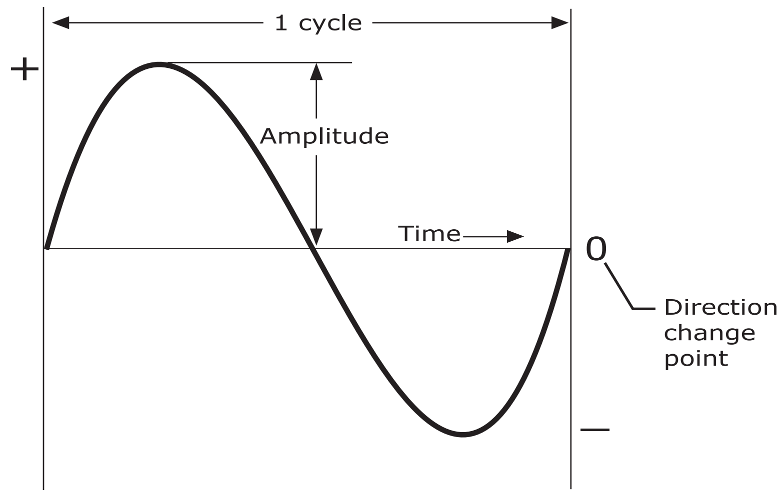
The standard commercial and residential main power frequency differs depending on the region. The two main frequencies are 60 hertz (Hz [cycles per second]) and 50 Hz. Generally these can be attributed to North America (60 Hz) and the other regions of the world (50 Hz). Always confirm with the authority having jurisdiction (AHJ) the main frequency for the region.

For each sine wave in ac, the voltage begins at zero level and increases to its maximum positive value before dropping back to the zero level, where the voltage becomes negative. The voltage continues to track in the negative level to reach a maximum negative value; it then becomes less negative, until it reaches the zero level again and completes the cycle (see Figure 1.1). Although the voltage has gone to zero twice each cycle, the eyes cannot perceive the rapid increase and decrease of the voltage and the accompanying flicker of a lamp.

Direct current (dc) refers to a steady value that does not change the polarity of the voltage or the direction of the current. It rises to its maximum value when switched on and remains there until the circuit is interrupted. A battery is an example of a dc source.

Terminology, continued

Figure 1.1
Analog sine wave



Electromagnetics

All electrical activity produces magnetic energy. Unwanted coupling of this energy can be minimized with proper design and installation methods. The subjects of EMI and radio frequency interference (RFI) are very complex. However, in most cases involving telecommunication infrastructure, the adverse effects can easily be minimized with appropriate media, proper installation procedures, and approved grounding and bonding methods.

Varying levels of EMI/RFI can cause problems including minor signal corruption, component malfunction, equipment failure, property damage, injury to personnel, and loss of life. As a result, it has both technical service and safety issues. Nearly all circuit noise can be directly or indirectly traced to EMI and/or RFI sources.

- Electromagnetic interference (EMI)–EMI is the random, unwanted energy that is inducted into a conductor from an external source. In ITS, that source could be external to the cable (e.g., other cables [alien crosstalk (AXT)], motors, fluorescent lighting, switching power supplies) or internal to the cable (e.g., from another pair within the sheath [crosstalk] or from the cable's shield, screen, or other metallic component that is improperly bonded and grounded).
- Radio frequency interference (RFI)–RFI is similar to EMI. All electromagnetic sources have a radio component. Usually this radio component is less intense than the EMI component (i.e., except for lighting, where both components are very strong) and, therefore, not a major factor if EMI has been properly addressed. However, there are many common sources of strong RFI including arc-welding, unshielded spark plugs, and arcing contacts.

Terminology, continued

Frequency

Frequency is defined as the number of cycles a signal is repeated in a given time period. Typically, an ac signal is shown as a sine wave (see Figure 1.1). If the unit of time is equal to 1 second (s), the frequency is stated in hertz (Hz).

The following are frequency unit sizes and names:

- 1 cycle in 1 second = 1 Hz
- 60 cycles in 1 second = 60 Hz
- 1000 cycles in 1 second = 1 kHz (kilohertz)
- 1 million (1,000,000) cycles in 1 second = 1 MHz (megahertz)
- 1 billion (1,000,000,000) cycles in 1 second = 1 GHz (gigahertz)
- 1 trillion (1,000,000,000,000) cycles in 1 second = 1 THz (terahertz)

Although humans can hear frequencies that range from 20 Hz to 20,000 Hz, typical voice-grade electrical transmission is generally limited to 100 to 4000 Hz. Transmission is generally limited to the range of 300 Hz to 3400 Hz, which covers the majority of the spoken voice range under normal conversational conditions.

Bandwidth

Bandwidth is the information-carrying capacity of a system. The end-to-end bandwidth of a system is related to the respective bandwidths of its component parts. The bandwidth or capacity of a system will also vary depending on its length.

Signal

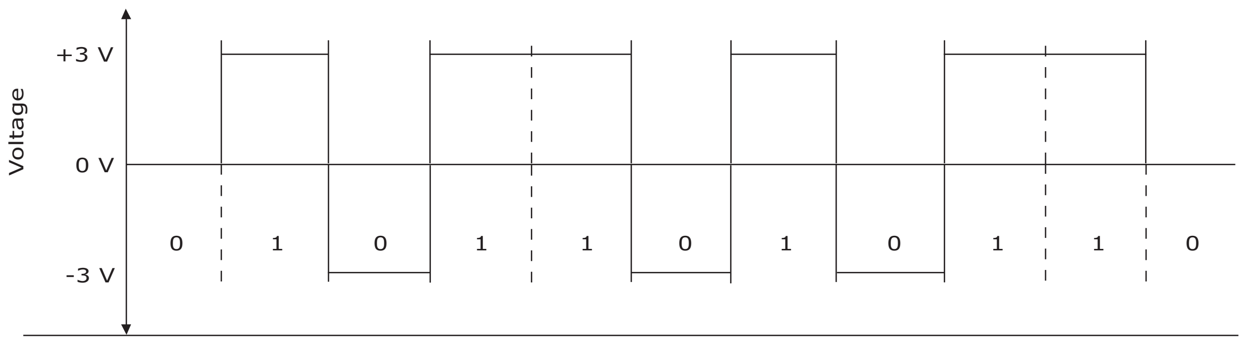
The information transmitted by a telecommunications system can originate in two fundamental forms—digital and analog. Digital data is represented by a string of bits, whereas analog data (e.g., a speech waveform) is represented by the continuous variation of the data.

- Analog signal–Analog is derived from the term analogous, which means "similar to." Analog transmission uses continuously varying electrical signals that directly follow or are similar to the changes in loudness (amplitude) and frequency (tone) of the input signal (e.g., the human voice). For instance, the transmitter of a telephone converts sound waves to an analog electrical signal that varies in amplitude (signal strength) directly with the loudness of the voice and varies in frequency directly with the tone of the voice.

Terminology, continued

- Digital signal–A digital signal is a discontinuous signal that changes from one state to another in a number of discrete (single) steps within fixed bit framing time slots (see Figure 1.2). In its basic form, there are two states or signal levels—on and off, where the "on" translates to a digit 1 and "off" is seen as a zero level corresponding to the digit 0. Other means can be used to represent the two states (e.g., a positive and a negative voltage).

Figure 1.2
Digital signal



The digital message is made up of a sequence of these digital pulses (bits) transmitted at regular and defined time intervals. These bits are usually rectangular in shape. Therefore, digitally transmitted information is an encoded representation of input, unlike analog transmissions, which reproduce an analog input in both frequency and amplitude.

Digital Transmissions

The basic unit of digital information is a bit (a contraction of the term binary digit). It is used to indicate the existence of two (binary) states or conditions (on or off). In older, slower devices current flow could be controlled, indicating an on or off state. However, in modern devices, controlling the flow of electrical current to indicate on and off states is very inefficient.

It is much more efficient to change a voltage level of an existing current flow than to establish a new current flow each time a pulse is needed. In modern electronics, this on/off state is accomplished with an electrical voltage pulse within a predefined time slot, which is greater than a continuous base or reference level (voltage) present during an entire message transmission.

NOTE: This base voltage is often shown on graphs as a zero reference voltage for simplicity, but it is actually a continuous current flow of a known and very stable voltage level (i.e., 24 V and 48 V are common).

Terminology, continued

EXAMPLE:

When a device first starts a transmission, it will employ a nominal base voltage of some level (e.g., 24 V). A pulse of + 3 V would indicate an on state and the line voltage would rise from 24 V to 27 V. When the voltage level returns to the 24 V base, it would represent an off state.

This example explains how a negative voltage pulse would work (unipolar nonreturn-to-zero [NRZ]). If a system were bipolar (+ 3 V and – 3 V), then – 3 V would indicate the change in base voltage from 24 V to 21 V and represent a negative pulse or on state. In this case, an on state will be either + 3 V (27 V) or – 3 V (21 V) while an off state would be 24 V.

When a series of bits are grouped into a coded sequence (usually 4 or 8 bits), they make up basic building blocks that can convey information. The information that is conveyed depends on how a programmer references these building blocks to a table of information.

Modem

The transmission of digital data (from a personal computer [PC]) can be accomplished on a direct digital basis over a digital circuit or it can be converted to an analog signal with a modulator/demodulator (modem). These modems convert the digital signal's 1s and 0s into two separate analog frequencies, each representing a 1 or a 0. This analog signal is then transmitted over a standard telephone circuit. The process is reversed at the opposite end to recreate the original digital signal.

Codec

The transmission of analog data (from video devices) can be converted from analog format to digital with the use of coder/decoder (codec). These codecs convert the amplitude changes of various frequencies into a digital format for transmission over digital transmission media. The process is reversed at the opposite end to recreate the video images.

Analog to Digital Conversion

For analog inputs (e.g., voice), the conversion to a digital signal for transmission over a digital media involves a sampling process. An analog signal is sampled often enough that, when recreated, there is an acceptable facsimile of the original signal's data.

The most common process for voice conversion is called pulse code modulation (PCM). PCM samples the analog voice signal 8000 times per second to create a digital voice channel of 64,000 bits per second. All carriers use this method. However, other methods to compress the voice into smaller data streams are becoming popular because of voice over Internet protocol (VoIP), especially when used with wireless fidelity (Wi-Fi).

Terminology, continued

Megahertz (MHz) and Megabit (Mb)

It is important to highlight the relationship between megahertz and megabits.

MHz quantifies the bandwidth of the cable (e.g., 100 MHz category 5e cable). This relates to the information-handling capability of the media (i.e., the size of the highway).

Mb refers to the number of bits of information that can be transported over the media (i.e., vehicles on the highway).

The number of bits that can be transported over the media is determined by the type of encoding scheme used in a system. With a simple encoding scheme, one bit may be transported by one cycle (a single vehicle). More complex encoding schemes may have multiple bits of information transported in a single cycle (multiple vehicles on a car transporter).

Decibel (dB)

A measure of analog signal strength is a bel, named in the honor of telephone pioneer Alexander Graham Bell. The term is inappropriately large for ITS work, so a decibel (dB) or one tenth of a bel is used. It is not an absolute value but a ratio of two signals and may be used for comparing power, current, or voltage.

System gain and attenuation are typically stated as dB gain or dB loss. For example, an amplifier may have a power gain of 10 dB, or a connector in a cabling system may have a loss of 0.3 dB. Decibels express a ratio of two values, but the ratio is not linear.

The dB is a logarithmic (as opposed to linear) function that allows large variations to be shown in very small increments. A good example is the human ear, which can typically sense a 3 dB change in loudness.

Increases or decreases of 3 dB will result in a doubling or halving of the power. Increases or decreases of 6 dB will cause a doubling or halving of the voltage.

Increases or decreases of 10 dB for power, and 20 dB for voltage or current, will cause an increase or decrease of 10 times the original value. This moves the decimal point one place forward or backward. For example, if the input power is equal to 1 W, a decrease of 10 dB will have a value of 0.1 W; however, an increase of 10 dB will have an output of 10 W.

The formula for computing dB is:

$$dB = 10 \log (P_1 / P_2)$$

Where P_1 is the device output power and P_2 is the input power.

Cabling system parameters that use dB as a measurement of performance include:

- Crosstalk—The larger the dB value, the better.
- Insertion loss (measured attenuation)—The smaller the dB value, the better.
- Structural return loss—The higher the dB value, the better.
- Channel separation—The higher the dB value, the better.

Within the telephony industry, a theoretical standard level ratio of measurement is 0 dBm. This reflects a zero decibel reading from one milliwatt (1 mW) of power at a frequency of 1004 Hz across an impedance of 600 ohm.

Copper Cabling Media

Overview

With any copper cabling medium, a sufficient level of signal must be coupled through the medium from the transmitter to the receiver to drive the receiver.

The most effective and efficient transfer of a signal will occur at interfaces and connection points where all components have the same characteristic impedance.

This section describes the electrical properties that make up characteristic impedance and how characteristic impedance can be impacted by hardware, design, and cabling installation methods or procedures.

American Wire Gauge (AWG)

Through usage and industrial standardization, the American wire gauge (AWG) sizing system has become generally accepted worldwide.

The AWG system is important because it provides a standard reference for comparing various conductor materials.

Basis of the American Wire Gauge (AWG) Numbering System

Historically, the sizes in the AWG system roughly represent the number of steps that were involved in the process of wire drawing. Therefore, the AWG numbers and the size of the wires they represent have an inverse relationship.

In the AWG system:

- Smaller numbers denote larger wires (because there are fewer drawing steps involved).
- Larger numbers denote smaller wires (because there are more drawing steps involved).

Solid Conductor Diameters

The conductor diameters for the AWG system are based upon fixed diameters for the smallest size (36 AWG = 5 mil) and the largest size (4/0 = 460 mil), where 1 mil is equal to 0.0254 mm (millimeters [0.001 inches (in)]). The diameters for the intermediate sizes are derived from the largest size or from the smallest size according to a geometric progression.

For example, if beginning with the fixed diameter of 4/0, each smaller size conductor is derived from the previous size by multiplying it by a factor of 1/R = 0.89052571 (e.g., 4/0 = 460 mil, 3/0 = 460/R, 2/0 = $460/R^2$, 1/0 = $460/R^3$, 1 = $460/R^4$, … 36 = $460/R^{39}$).

The AWG has become a standard for specifying and measuring conductor diameter. Smaller gauge numbers represent larger wire diameters:

- A gauge change of 1 approximately doubles or halves the conductor’s cross sectional area.
- A gauge change of 3 approximately doubles or halves the conductor’s resistance.
- A gauge change of 6 approximately doubles or halves the conductor’s diameter.

American Wire Gauge (AWG), continued

Table 1.1 is based on precise AWG calculations.

Table 1.1
Conductor size

AWG	1 Mil of an Inch	Conductor Size/mm Diameter	Conductor Size/in Diameter	CSA mm^2	Standard Conductor Sizes mm^2	dc Resistance (ohms per 305 m [1000 ft])	dc Resistance (ohms per 1 m [39 in])
4/0	460.000	11.684	0.46	107.22	120	0.05	0.000164042
3/0	409.642	10.405	0.41	85.03	95	0.06	0.00019685
2/0	364.797	9.266	0.365	67.43	70	0.08	0.000262467
1/0	324.861	8.251	0.325	53.48	70	0.10	0.000328084
1	289.297	7.348	0.289	42.41	50	0.13	0.000426509
2	257.626	6.544	0.258	33.63	35	0.16	0.000524934
3	229.423	5.827	0.229	26.67	35	0.20	0.000656168
4	204.307	5.189	0.2045	21.15	25	0.25	0.00082021
5	181.941	4.621	0.182	16.77	25	0.30	0.000984252
6	162.023	4.115	0.162	13.30	16	0.4	0.001312336
7	144.285	3.665	0.144	10.55	16	0.5	0.00164042
8	128.490	3.264	0.128	8.37	10	0.6	0.001968504
9	114.424	2.906	0.114	6.63	10	0.8	0.002624672
10	101.897	2.588	0.102	5.26	6	1.0	0.00328084
11	90.742	2.305	0.091	4.17	6	1.3	0.004265092
12	80.808	2.053	0.081	3.31	4	1.6	0.005249344
13	71.962	1.828	0.072	2.62	4	2.0	0.00656168
14	64.084	1.628	0.064	2.08	2.5	2.5	0.0082021
15	57.068	1.450	0.057	1.65	2.5	3.2	0.010498688
16	50.821	1.291	0.051	1.31	1.5	4.0	0.01312336
17	45.257	1.150	0.045	1.04	1.5	5.0	0.016404199
18	40.303	1.024	0.0403	0.82	1	6.4	0.020997375
19	35.891	0.912	0.0359	0.65	1	8.1	0.026574803

American Wire Gauge (AWG), continued

Table 1.1, continued
Conductor size

AWG	1 Mil of an Inch	Conductor Size/mm Diameter	Conductor Size/in Diameter	CSA mm^2	Standard Conductor Sizes mm^2	dc Resistance (ohms per 305 m [1000 ft])	dc Resistance (ohms per 1 m [39 in])
20	31.961	0.812	0.032	0.52	1	10.1	0.033136483
21	28.462	0.723	0.0285	0.41	0.5	12.8	0.041994751
22	25.347	0.644	0.0253	0.33	See Notes	16.2	0.053149606
23	22.572	0.573	0.0226	0.26	See Notes	20.3	0.06660105
24	20.101	0.511	0.0201	0.20	See Notes	25.7	0.084317585
25	17.900	0.455	0.0179	0.16	See Notes	32.4	0.106299213
26	15.941	0.405	0.0159	0.13	See Notes	41.0	0.134514436
27	14.196	0.361	0.0142	0.10	See Notes	51.4	0.168635171

AWG = American wire gauge
CSA = Cross-sectional area
dc = Direct current
ft = Foot
in = Inch
lb = Pound
m = Meter
mil = Millionth
mm = Millimeter
mm^2 = Square millimeter

NOTES: Power cables generally do not go below 0.5 mm^2.

Control cables generally do go below 0.5 mm^2.

Resistance

For metallic cables, the electrical energy of the signals is typically transmitted over copper conductors. Copper is preferred, because it offers less resistance to the flow of electrical energy when compared with most other metals and is relatively economical.

Resistance is the facility of a conductor to resist the flow of electricity through it. Resistance is expressed in ohms. One ohm of resistance will allow one ampere of current to flow when one volt of electrical pressure is applied. This is stated mathematically in Ohm's Law (see Figure 1.3) as:

$$V = I \times R$$

or

$$R = V / I$$

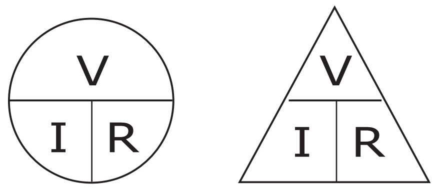
or

$$I = V / R$$

Where V is voltage in V, I is current in A, and R is resistance in ohms. Mil is the units of length, equal to 0.001 in, used in measuring the diameter of wire.

Resistance, continued

Figure 1.3
Ohm's Law



V = Voltage in volts
I = Current in amps
R = Resistance in ohms

Ohm's law values are easily solved. Place your finger over I, and you will see V is divided by R. Place your finger over R, and you will see V is divided by I. Place your finger over the V, and you will see that I is multiplied by R.

Higher temperatures increase the conductor resistance by approximately two percent for each 5.5 degrees Celsius (ºC [10 degrees Fahrenheit (ºF)]) rise.

Resistance changes in proportion to length (e.g., doubling the length of the cable doubles its resistance).

The diameter of the conductors of a pair is maintained at a close tolerance to keep any resistance unbalance to a minimum. Such unbalance contributes to undesirable distortion of the signal.

Inductance

Inductance is a property of an electrical force field built around a conductor that opposes any changes in current flow in a circuit, both ac and varying dc. When dc flows through a conductor, the field is steady. An ac signal causes the lines of force to constantly build and collapse. The opposition to varying current results in energy loss, particularly for high-frequency signals.

Inductive coupling is the transfer of energy from one circuit to another (e.g., power lines on a utility pole can inductively couple a power surge onto telephone cables).

The basic unit of inductance is a henry (H).

Capacitance

Capacitance is a property of conductors that allows storage of electrical charges when potential differences (voltages) exist between the conductors. The effect of capacitance is the voltage difference between two wires, which are separated by insulation. The insulation or dielectric (nonconductive material) separates the two wires resulting in a buildup (or storage of electrical charges) of capacitance between the wires.

Capacitance is measured in farads (F). Normally, capacitors are measured in microfarads (µF [one millionth of a farad]), nanofarads (nF [one billionth of a farad]), or picofarads (pF [one trillionth of a farad]).

Cable normally exhibits some level of capacitance. Typically, balanced twisted-pair will have a value of 10 to 20 picofarads per foot (pF/ft). However, capacitance in cable is considered undesirable and must be minimized.

Capacitance may be affected by improper cable installation. Because it is a very important element of the cable's characteristic impedance, changes in capacitance and inductance may degrade the quality of transmission through the cable.

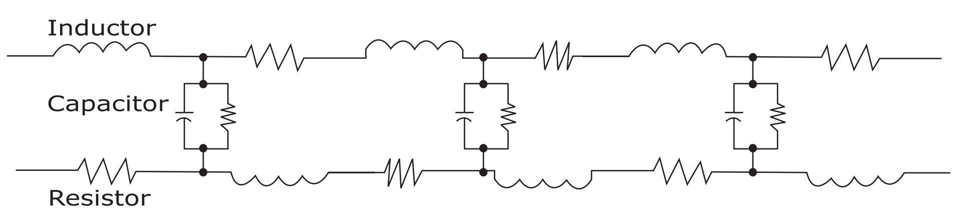
Impedance

In ac circuits, the total opposition to current flow is called impedance (Z_0). This is the combined effects of resistance (R), inductance (L), and capacitance (C) of the circuit.

Characteristic Impedance

Characteristic impedance is defined as the input impedance of a uniform analog transmission line of infinite length. An example of a transmission line is a balanced twisted pair of wires. To a signal, a transmission line appears as an accumulation of resistors, capacitors, and inductors (see Figure 1.4).

Figure 1.4
Schematic of a transmission line



Impedance, continued

Every cable or transmission line has characteristic impedance. The value of the characteristic impedance is determined by the:

- Material and the diameter of the conductors.
- Distance between the conductors.
- Insulating value (dielectric constant) of the materials separating them.

Cables are designed to achieve constant characteristic impedance independent of the cable length. For example, if a 30 meters (m [100 feet (ft)]) length of cable has characteristic impedance of 100 ohms, it will still be 100 ohms if the length is doubled or tripled for a given frequency.

All components of a system must reference the same value of input and output impedance for maximum signal (energy) transfer to occur at the interface point. Impedance matching becomes even more critical at higher frequencies. Impedance matching is a common problem when assembling audio components.

Most balanced twisted-pair cables used for ITS exhibit a characteristic impedance of approximately 100 ohms ± 15 percent at 1 MHz at a temperature of 20 ºC (68 °F) and above. Shielded cable normally has more capacitance.

Insertion Loss (Attenuation)

Insertion loss (attenuation) is:

- The measure of signal loss resulting from the insertion of a component, link, or channel, between a transmitter and receiver (often referred to as attenuation).
- The measure of how much a signal is reduced in amplitude (voltage) as it is transmitted over cable.
- Measured in dB per unit length at a given frequency. As frequency or length increases, attenuation increases.
- A loss of usable signal to the load or receiver, the lower the dB value, the better. Higher attenuation means less available signal.

There are times when attenuation is added so that the signal is not too high at the receiver end. This is called padding down the circuit.

Return Loss

Return loss is a ratio expressed in decibels (dBs) of the power of the outgoing signal to the power of the reflected signal. When the termination (load) impedance does not match (equal) the value of the characteristic impedance of the transmission line (e.g., 100-ohm impedance), some of the signal energy is reflected back toward the source and is not delivered to the load.

The amount of reflected energy is affected by the degree of impedance mismatch between the load and the line. The better the impedance match, the less energy is reflected. Reducing the reflected signal increases the amount of power or signal level transferred to the load.

Return Loss, continued

For cabling systems, reflections result when impedance discontinuities exist along the line and at the end termination. Standards provide for component impedance (e.g., cable, connectors) of 100-ohm ± 15 percent. Impedence variations result from cable termination to connector's installation variables (e.g., cable bends, stresses imposed on cables), as well as variations within and between cables and connectors. These variations can be measured and expressed in terms of return loss.

In systems where a single pair is used for bidirectional signaling (i.e., transmission from both ends of the pair at the same time), any reflected signal is added to the transmitted signal in the form of noise.

Crosstalk

The unwanted transfer of a signal's electromagnetic energy from one or more circuits to other circuits is called crosstalk. This transfer may be between pairs in close proximity (e.g. pair-to-pair crosstalk) or between adjacent cables (e.g., alien crosstalk [AXT]). Crosstalk is decreased by pair twists, cable lay, shielding, and physical pair separation, all of which are achieved during the cable manufacturing process.

The level of crosstalk increases when frequency or cable length increases, although this increase is not directly proportional.

Three basic types of crosstalk are of interest for balanced twisted-pair cabling:

- Near-end crosstalk (NEXT)
- Far-end crosstalk (FEXT)
- Alien crosstalk (AXT)

Near-End Crosstalk (NEXT)

NEXT is a measure of the unwanted signal coupling from a transmitter at the near end into another pair measured at the near end. When NEXT measurements are made with field test equipment, there are six combinations of pair-to-pair NEXT associated with a 4-pair cabling link or channel. These pair combinations are:

- Pair 1–Pair 2.
- Pair 1–Pair 3.
- Pair 1–Pair 4.
- Pair 2–Pair 3.
- Pair 2–Pair 4.
- Pair 3–Pair 4.

Far-End Crosstalk (FEXT)

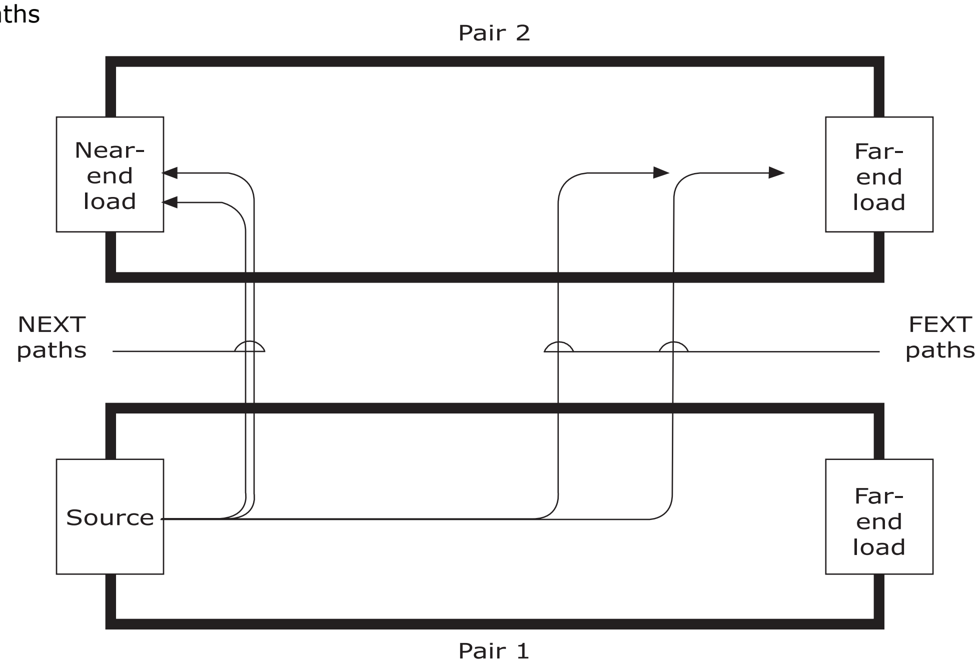
FEXT is a measure of the unwanted signal coupling from a transmitter at the near end into a neighboring pair measured at the far end. To measure FEXT, apply a disturbing signal on one pair at the near end and measure the signal transfer level on the disturbed pair at the end of the cable. FEXT is measured and expressed in dB at the opposite end from which the source signal is transmitted.

Crosstalk, continued

Figure 1.5 illustrates both NEXT and FEXT crosstalk paths for two pairs.

When a cable contains more than four pairs (e.g., multipair backbone cables), the calculation for crosstalk performance must take into account that these additional pairs are carrying electrical signals and could provide multiple disturbing paths. Far-end crosstalk and near-end crosstalk are expressed in dB.

Figure 1.5
Crosstalk paths



FEXT = Far-end crosstalk
NEXT = Near-end crosstalk

The lower the quantity of signal transferred between circuits, the smaller the received-to-transmitted signal ratio and the larger the dB crosstalk loss value.

ELFEXT is the measure of the unwanted signal transfer (coupling) that is assessed by applying a signal on one pair at the near end and measuring the signal transfer level on any disturbed pair at the receiving end of the cable. ELFEXT is measured and expressed in dB at the opposite end from which the source signal is transmitted.

The value for ELFEXT will vary depending upon the length of the cable. In order to obtain consistent values for ELFEXT, regardless of cable length, insertion loss must be factored into the measurement. The insertion loss of the disturber pair is subtracted from the FEXT measurement and reported as ELFEXT.

Crosstalk, continued

Alien Crosstalk (AXT)

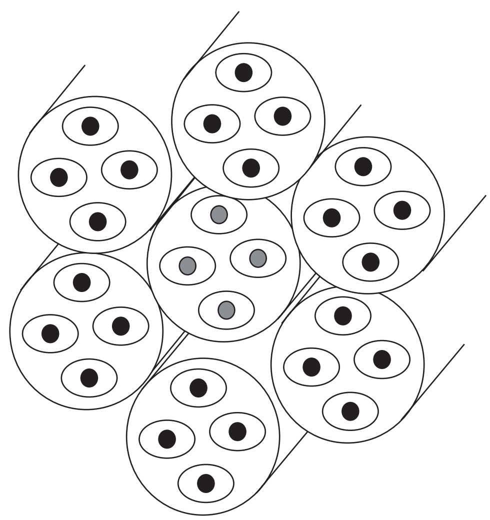
AXT is the unwanted signal coupling from a disturbing pair of a 4-pair cable channel, permanent link, or component to a disturbed pair of another 4-pair channel, permanent link, or component.

There are several variants of AXT. Figure 1.6 depicts the six-around-one, laboratory test methodology that is used to qualify cables for AXT compliance. These AXT measurements are made while the cables are placed in this configuration.

To limit the effect of AXT, bundling parallel cables (known as combing) should be limited and only done when required within the telecommunications room (TR)/equipment room (ER).

NOTE: The practice of "combing" the cables the entire length of the pathway will increase the amount of alien crosstalk and should be held to a minimum.

Figure 1.6
Six-around-one alien crosstalk measurements configuration



Nominal Velocity of Propagation (NVP)

This is a ratio of the speed of transmission along a cable relative to the speed of light in a vacuum. It is often stated in percentages. The base of the measurement is the speed of light in a vacuum. Certain test equipment uses NVP to determine the length of a cable.

Propagation Delay

This is the time interval required for a signal to be transmitted from one end of a circuit to the other. For 100-ohm 4-pair cables, the maximum allowable propagation delay is measured at all frequencies between 1.0 MHz and the highest referenced frequency for a given cable category. The delay is expressed in nanoseconds (ns) per 100 m (328 ft).

Delay Skew

Delay skew is the difference in the propagation delay between the slowest and fastest pairs within the same cable sheath. This measurement is expressed in ns per 100 m (328 ft).

Insulation

Copper wires must be physically separated. In the case of a single pair of wires, contact of the two wires (short circuit) will prevent the signal from traveling down the transmission line. The selection of material to cover the copper involves economics as well as tradeoffs in characteristics desired for the application and installation environment.

An electrically efficient insulation is nearly always desired, but a tradeoff may be required (e.g., to obtain insulation capable of meeting plenum cable requirements). Similarly, less effective insulation may be used to secure more physically robust characteristics.

NOTE: Efficient insulation is defined as a material where any losses of the transmitted signal due to losses associated with the insulation itself are minimal.

The insulation materials selected can affect the physical size of the completed cable, and also determines two of the four primary electrical cable characteristics:

- Mutual capacitance (C) of a pair
- Conductance (G)

Mutual capacitance depends on the conductor’s insulating material as well as the material’s diameter (thickness).

The conductance of a cable indicates the potential for current to leak through the insulation. Conductance is inversely related to resistance.

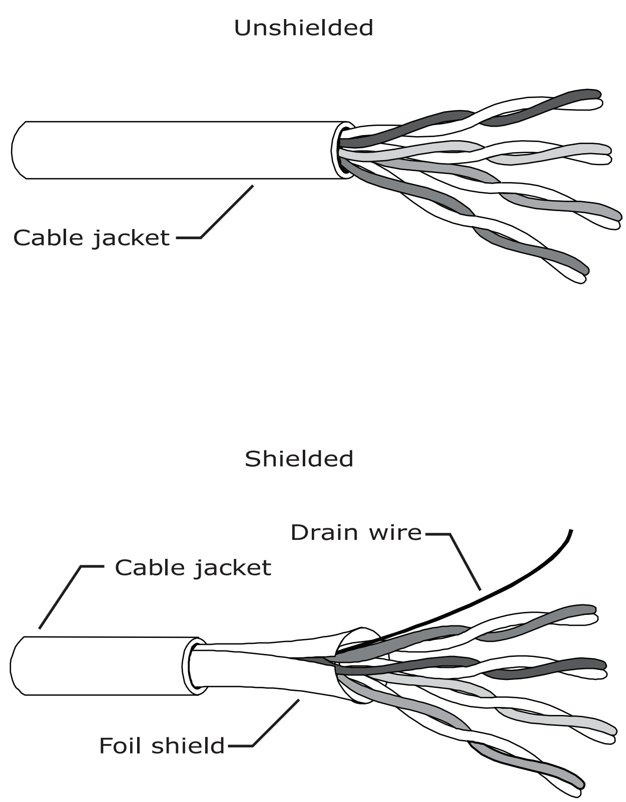
Pair Twist

To maintain consistent transmission quality in an ITS cable, the two wires of an insulated copper pair are uniformly twisted together. The length of this twist (or pair lay or pitch) usually varies from approximately 6 mm (0.25 in) to 200 mm (8 in). The ITS cabling is manufactured so that no two pairs in a cable will have the same pair lay length. Because of the different twist rates in a multipair cable, the physical length of untwisted pairs is not equal.

Both the effects of capacitance unbalance and electromagnetic induction are improved by twisting the pairs.

By proper design and twisting of the pairs, detrimental crosstalk and noise are minimized. It is necessary that the ITS installer recognize the importance of each individual pair twist and to maintain the same pair twist for each individual pair when terminating the pairs to the connecting hardware. Pair twist may vary from pair to pair within a given cable (see Figure 1.7). The objective is minimizing pair disturbance.

Figure 1.7
Typical balanced twisted-pair cable



Shielding

Copper cabling may or may not involve a metallic covering (shield) over the pairs (see Figure 1.8). Certain systems use shielded cables or shielded pairs. Backbone cables may use an overall shield.

The shield is used to:

- Reduce the level of the signal radiated from the cable.
- Minimize the effect of external EMI on the cable pairs.
- Provide physical protection.

The shielding material used, its thickness, and relative coverage (limited number of perforations) determine the effectiveness of meeting the shield's goals. Types of shield include metallic foil, copper braids, solid tubing, drain wires, and coupled bonding conductors.

The shield's characteristics are as follows:

- Foil will typically block higher frequencies (30 MHz and higher).

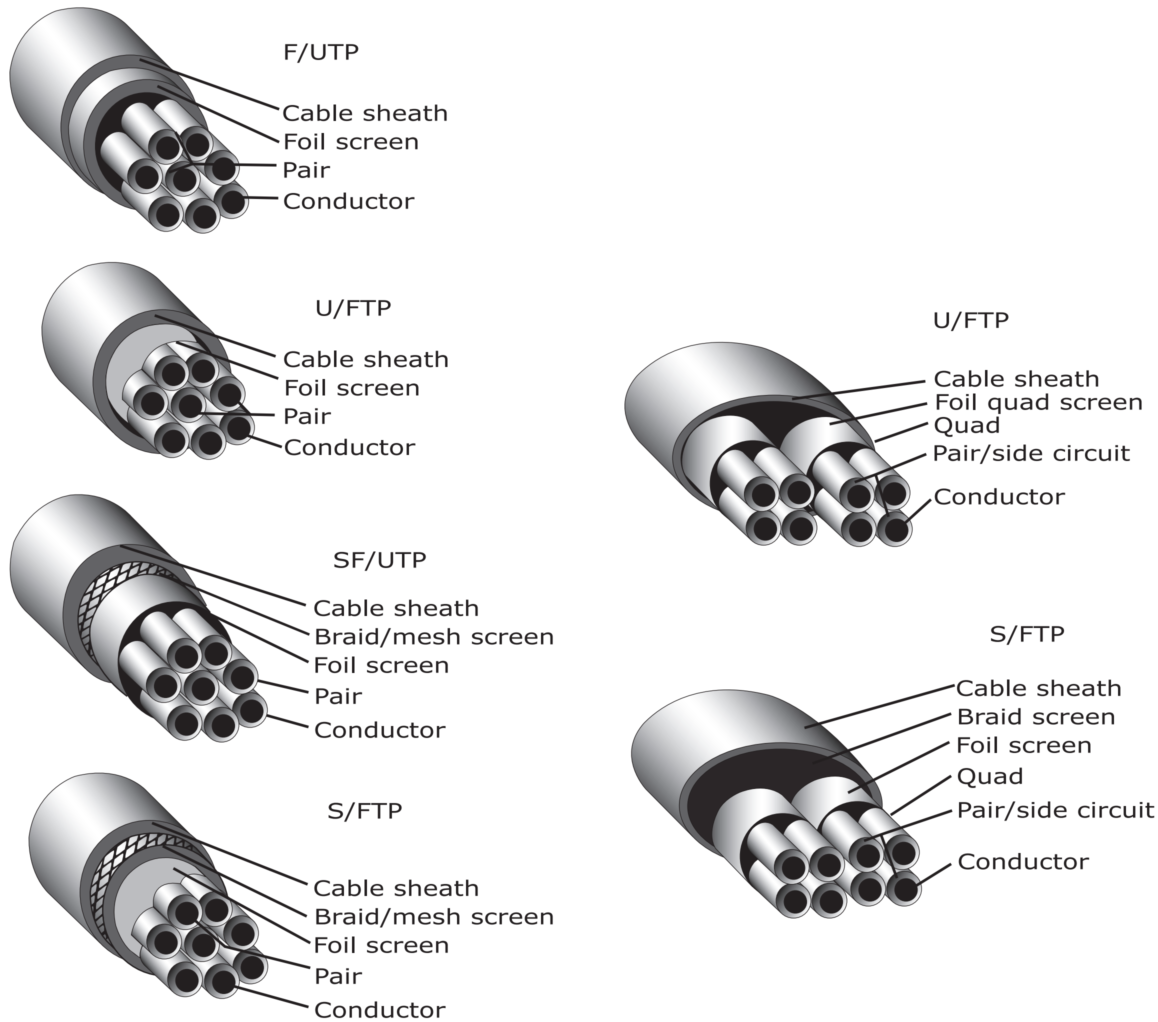
  NOTE: Drain wire will effectively drain the current on the shield.

- Copper braids will block lower frequencies.
- Solid tubing will block all frequencies.
- Coupled-bonding conductor (CBC) may help divert all induced frequencies from susceptible cables.

Shields are effective only when continuity is assured and they are bonded per codes and standards.

Shielding, continued

Figure 1.8
Shielding



F/UTP	=	Overall foil screened with unshielded twisted-pair
S/FTP	=	Overall braid screen with foil screened twisted-pair
SF/UTP	=	Overall braid and foil screened with unshielded twisted-pair
U/FTP	=	Overall unshielded twisted-pair with foil screened twisted-pair

Coaxial Cables

Coaxial cables derive their name from the fact that there is an insulated (centrally located) conductor surrounded by an overall metallic covering. The geometry of such a construction inherently provides reduced external interference and radiation protection; however, the metallic covering is not a shield—it is a conductor in the circuit.

Hardware

Although much of the information in the previous sections described the characteristics of copper cable transmission media, attention should be given to the connecting and terminating hardware used to establish the total channel. Crosstalk, signal loss, and other detriments to the performance of the network can be attributed to these devices.

All components within a link or channel (e.g., cable, jacks, interconnection points, if required, and, specifically, termination methods) must match for a circuit to support high-speed transmissions. Some manufacturers stress the need to use one product line or model to meet higher data speeds. The ITS installer must be aware of any specific requirements or limitations of the equipment to be installed.

Optical Fiber Cable Media

Overview

Optical fiber cables are used in backbone and horizontal applications. When high data rates are required or an all-dielectric construction is desirable, optical fiber cable offers characteristics that can make them the media of choice. Transmission of information through optical fiber cables is not degraded by crosstalk, noise, lightning, and most EMI problems. However, like copper cables, attenuation (loss of signal) and environmental considerations are of concern for optical fiber systems.

The primary difference between copper and optical fiber as a transmission medium is that pulses of light consisting of photons are injected into the optical fiber, as opposed to the electron flow in a copper-based cable.

The inner portion of the glass optical fiber used for carrying the light pulse is called the core, and the surrounding glass layer is called the cladding. The purpose of the cladding is to confine the light within the core by creating a reflective boundary.

Optical fibers are classified as either singlemode or multimode. Singlemode optical fibers have a relatively small diameter featuring a core of 8 to 11 micrometers (µm) and a cladding diameter equal to 125 µm. Lasers have a narrow light beam and can focus 100 percent of the light beam down the core of the optical fiber. Multimode has a larger core diameter (e.g., 50 or 62.5 µm) with the cladding at 125 µm. The light is restricted to a single path or mode in singlemode optical fibers, whereas the larger diameter multimode has many paths or modes.

Current standards support both 50/125 µm and 62.5/125 µm as well as singlemode optical fiber cables. While the 50/125 µm cable has a greater bandwidth, 62.5/125 µm cable has been the leader in the marketplace, and most in-place systems utilize it while most newer networks use 50/125 µm.

Singlemode optical fiber systems are frequently used for long-haul transmission systems, data systems requiring high bandwidth, and many optical fiber-based video distribution systems. The lasers used to drive the signal over singlemode are generally more expensive than the light emitting diode (LED) and vertical cavity surface emitting laser (VCSEL) based multimode systems.

This section addresses multimode cable, because it is the type normally selected for short distances (less than 2.0 kilometers [km (1.2 miles [mi])]).

Two characteristics of particular importance in the transport of information over optical fiber media are bandwidth and attenuation. Bandwidth and attenuation relate to the transmission of light pulses over optical fiber cables.

Overview, continued

Tables 1.2 and 1.3 show the minimum bandwidth (capacity) and attenuation (insertion loss) per kilometer for each of the most commonly used optical fiber types.

Table 1.2
Optical fiber cable bandwidth performance parameters

	Multimode	850 nm OFL	850 nm RML	1300 nm	1310 nm	1550 nm
FDDI	62.5/125 µm	160 Hz•km	N/A	400 MHz•km	N/A	N/A
OM1	62.5/125 µm	200 Hz•km	N/A	500 MHz•km	N/A	N/A
OM2	50/125 µm	500 MHz•km	N/A	500 MHz•km	N/A	N/A
OM3	50/125 µm Laser optimized	1500 MHz•km	2000 MHz km	500 MHz•km	N/A	N/A

µm = Micron
FDDI = Fiber distributed data interface
Hz = Hertz
km = Kilometer
MHz = Megahertz
MHz•km = Megahertz kilometer
N/A = Not applicable
nm = Nanometer
OFL = Overfilled launch
OM = Optical multimode
RML = Restricted modal launch

NOTE: The terms overfilled launch (OFL) and restricted modal launch (RML) relate to the method of presenting the light into the optical fiber. This is explained in more detail in Chapter 6: Optical Fiber Structured Cabling System.

Table 1.3
Optical fiber cable attenuation performance parameters

	Multimode	850 nm	1300 nm	1310 nm	1550 nm
OM1	62.5/125 µm	3.5 dB/km	1.5 dB/km	N/A	N/A
OM2	50/125 µm	3.5 dB/km	1.5 dB/km	N/A	N/A
OM3	50/125 µm Laser optimized	3.5 dB/km	1.5 dB/km	N/A	N/A

µm = Micron
dB = Decibel
km = Kilometer
N/A = Not applicable
nm = Nanometers
OM = Optical multimode

NOTE: The information transmission capacity of the optical fiber, as measured by the optical fiber manufacturer, can be used by the cable manufacturer to demonstrate compliance with this requirement.

Bandwidth

The modal bandwidth of an optical fiber provides a measure of the amount of information an optical fiber is capable of transporting. Modal bandwidth is described in terms of megahertz•kilometer (MHz•km).

The modal bandwidth of a multimode optical fiber is characterized by the frequency at which the amplitude drops 3 dB. A typical 50 µm, OM2 optical fiber features approximately 500 HMz for a 1 km (0.6 mi) length at a given frequency (e.g. 850 nm). This is expressed as a modal bandwidth of 500 MHz•km @ 850 nm.

Increasing either the length of the cable or the modulation frequency of the light source decreases the modal bandwidth and, therefore, the information-carrying capacity of the transmission path.

Dispersion

Dispersion is the widening or spreading out of the modes in a light pulse as it progresses along the optical fiber. If the pulse widens too much, it can overlap at the receiver and make it impossible to distinguish one pulse from another. As errors occur in the reading of pulses (bits), the bit error rate (BER) increases. Bandwidth is, therefore, limited by total dispersion that is the sum of modal dispersion and chromatic dispersion.

Modal Dispersion

Modal dispersion in multimode optical fibers is the major factor in the total dispersion. It is the result of different lengths of the light paths taken by the many modes (multimode) as they travel down the optical fiber from the source to the receiver. Since portions of the signal arrive ahead of, or are delayed from, other portions of the signal, an individual light pulse may be spread out, making the identification of the light pulse at the far end questionable.

Chromatic Dispersion

Chromatic dispersion begins at the light source. The sources utilized to create the light pulses are either a laser, VCSEL, or LED and do not furnish a perfectly monochromatic (single wavelength) light. Thus, the light injected into the optical fiber media contains a number of slightly differing wavelengths.

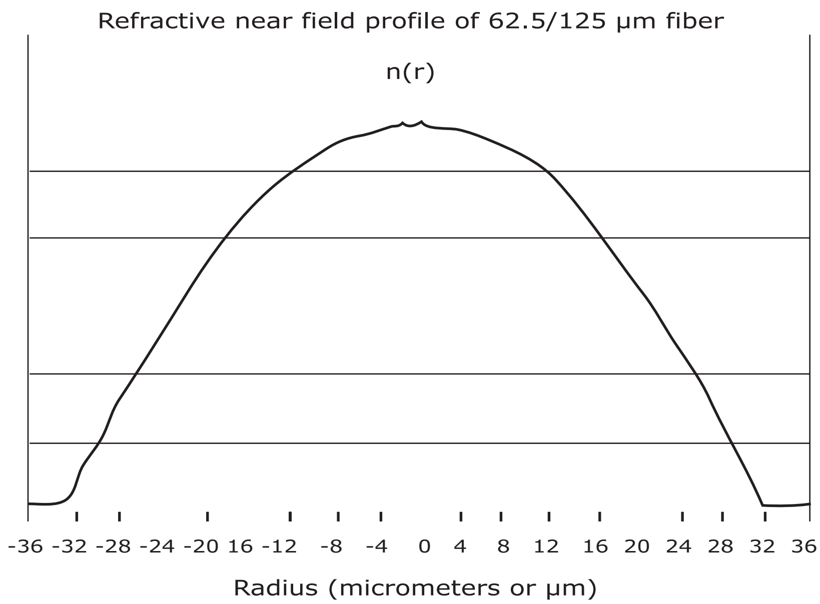
Inasmuch as the index of refraction of the glass optical fiber is not the same for different wavelengths, each travels through the optical fiber at a slightly different speed.

Modal dispersion tends to further broaden these pulses. Together these dispersion factors increase the BER and lower the effective bandwidth. Through the use of graded index optical fiber, the effects of modal dispersion are reduced but are not eliminated.

Differential Mode Delay (DMD)

Figure 1.9 illustrates the profile of a graded index core for 62.5 µm optical fiber. The curve for a 50 µm would look similar. Although a perfect curve is the objective, sometimes imperfections occur, as it can be seen at the top of this graph. These little imperfections are the cause of DMD.

Figure 1.9
Core profile—laser-certified optical fiber



n = Refractive index
r = Radius

Modal dispersion/modal bandwidth and DMD are associated with the optical fiber properties. When using a VCSEL transmitter, a better transmission path must be provided to ensure that the information arrives at the destination in an intelligible manner. Since an LED cannot be modulated fast enough to provide gigabit speeds, it becomes necessary to use lasers or VCSELs. VCSEL is a usual choice for local area network (LAN) environments due to its lower cost.

When using a VCSEL transmitter, multimode glass, and a detector, the information pulse starts out as acceptable. However, as the light pulse travels down the length of the optical fiber, the pulse starts to spread due to modal dispersion and any present DMD problems in the optical fiber. At some point along the optical fiber, the pulse becomes so spread out that intersymbol interference is experienced. When this happens, the information becomes unintelligible. This is common with conventional multimode, either 62.5 or 50 µm. Laser-optimized optical fiber glass effectively reduces the effects of DMD and is in widespread use in enterprise networks.

Attenuation

Light pulses in optical fiber cables are subjected to a loss in the power as the light pulses travel along the optical fiber. This attenuation occurs as a result of absorption of power by impurities within the glass itself and scattering of the light.

Losses due to scattering are caused by such factors as:

- Glass material.
- Core size variations (i.e., different manufacturers may have slight variations in core diameters).
- Variations in the interface between the core and cladding.
- Macrobends and microbends in the strands.
- In rare cases, very strong magnetic fields.
- Concentricity (i.e., the relationship of core and cladding that make up the optical fiber).

Optical fiber attenuation is referenced in decibel per kilometer (dB/km). It is proportional to length and is affected by the wavelength of the light contained in the pulse.

The mishandling or improper termination of optical fiber cable is frequently the cause of most unexpected attenuation. To provide a fully functional optical fiber transmission system:

- Maintain adequate bend radii.
- Use cable designed for the environment.

Common Safety Practices

Overview

It is every organization's responsibility to provide safety training for its employees and ensure that safety procedures are strictly followed. Safety training should be given on a regularly scheduled basis and not as a result of an injury.

Because of the daily hazards to which information transport system (ITS) cabling installers are exposed, it is vital that all ITS installers have a complete understanding of rescue and first aid procedures.

ITS installers must know their company's safety policies and practices and follow them while working. Be aware of any site-specific safety issues that affect a task. Pay close attention and ask questions during every company or job-site safety meeting.

Each employee should ensure that workplace safety is part of the job. Do not depend only on the efforts of others to ensure job safety.

When working, consider the possible effects of every action. This is especially important for actions that could have consequences in remote locations (e.g., turning the power on or off or activating distant machinery).

This section is not intended to provide complete coverage of the issue of workplace safety. It is the responsibility of the ITS installer to be aware of regulations, standards, and local policies and to play a primary role in practicing safety.

Most countries have national and often local requirements that must be followed as a minimum by the ITS installer. In all instances, the ITS installer should seek guidance from the authority having jurisdiction (AHJ) on the minimum requirements for safe work and employee health at work. On most projects, a site-specific safety practice must be followed.

Safety Awareness

The rules regarding the size of a company that must provide a specific type of safety program or training vary by state and, at times, by city.

However, the common themes for safety are:

- Common sense.
- Training.
- Caution.
- Awareness.
- Cooperation.
- Participation.

Safety Awareness, continued

Workplace safety is not simply remembering to wear a hard hat or knowing how to secure a heavy load. It includes a full range of health-related issues as well as physical safety aspects.

A significant amount of material related to safety in the workplace is available for individual workers and companies of all sizes. In addition to local or national safety requirements, most industry organizations and unions offer extensive resources on safety and safety planning.

This section provides a limited overview of some common health and safety issues related to the ITS field. It is up to individuals to seek additional information from their company, trade organization, or regulating body.

First Aid

All ITS installers should take courses in, and be capable of, providing:

- Basic first aid.
- Cardiopulmonary resuscitation (CPR).

The Red Cross and other nongovernmental organizations (NGOs) offer local courses in standard first aid and community CPR around the world.

First aid is the emergency aid or treatment given before medical services can be obtained. Training in first aid prepares individuals to act properly and help to save lives in the event of an emergency.

CPR is the emergency procedure used on a person who is not breathing and whose heart has stopped beating (i.e., has undergone a cardiac arrest).

First Aid, CPR, and the Law

Depending upon your location, the AHJ may have laws that govern how to approach and assist an injured person.

First aid and CPR certifications should be kept current. Certification cards have expiration dates that require refresher courses to renew.

First Aid Kits

First aid kits and portable eye wash stations must be part of the equipment for every job. Fresh water to rinse out debris or toxins may not be available during certain construction periods.

Ensure that the first aid kits are restocked after each use. Ensure eye wash stations have not passed their expiration dates. Promptly report any use of supplies from the first aid kit to the appropriate supervisor.

NOTE: Many companies keep additional first aid kits. At the end of each month, kits that have been used on the job are swapped with fully stocked kits. The used kits are then restocked and prepared for reuse.

First Aid, continued

First aid kits and eye wash stations should be accessible to all personnel on the job site. Prevent eye wash stations from freezing, because a frozen station is of little use in an emergency.

Written copies of the first aid procedures for exposure to a hazardous substance (e.g., material safety data sheet) should be brought to any job where ITS installers might be exposed to that substance. Review these procedures before the work begins.

Emergency Rescue

Emergencies allow no time for asking questions or learning from mistakes. There may only be one chance to save a life. An untrained rescuer often becomes an injured person of the situation that caused the emergency. For example, if a rescuer attempts to assist an unconscious injured person who is lying across an energized electrical circuit, the rescuer can become part of the circuit with the injured person.

Training in emergency rescue and first aid is often provided in one comprehensive course.

There are six basic steps to safely assist others without endangering yourself:

- Survey the scene—Check for fire, toxic fumes, heavy vehicle traffic, live electrical wires, a ladder, or swift-moving water. If the injured person is conscious, ask questions to get information.
- Notify someone—It is imperative to let someone know that help is needed and where the need is located. If a person attempts the rescue alone and becomes overwhelmed by smoke, electrocution, or unseen gases, additional help is needed.
- Secure the area—Make the area safe for the rescuer and the injured person. Locate and secure the power to the energized circuits and turn off the gas or water mains. Move the injured person to a safe area only if doing so would not further complicate the person's medical condition.

  NOTE: Do not move someone with a neck or back injury unless it is a life-threatening situation.

- Complete a primary survey of the injured person—Check the injured person's ABCs. A is for airway. (Open the injured person's airway. This is the most important action for a successful resuscitation.) B is for breathing. C is for circulation.
- Phone emergency medical service (EMS)—Direct someone to call EMS and relay all the information collected in the initial survey.
- Complete a secondary survey of the injured person—Perform CPR as needed and check for secondary minor injuries that may have been previously overlooked.

IMPORTANT: The rescue techniques outlined are basic and should only be used after receiving the proper training. Some rescues require specialized training and equipment.

Communication

Communication is an important part of any safety program. Attend and pay close attention to all safety meetings and safety equipment training. Ask questions.

On the job, ITS installers must communicate freely and clearly with everyone affected by their work and those whose work may affect them. These people include:

- Coworkers.
- Supervisors and the building management.
- Building occupants (if any).
- Other workers (e.g., construction, electric utility) on-site.

When the work is being performed in two locations (e.g., an electrical circuit is being switched off from one location to allow an ITS installer to work safely in another location), workers in each location should repeat each message and secure the confirmation that it was heard correctly before acting on the message. Never assume that related tasks have been performed—always obtain the confirmation.

NOTE: Portable radios use a limited number of frequencies; therefore, it is likely that different crews will be using the same frequencies. When using radios to communicate between two locations, workers should always confirm that they are talking to the correct person.

Be alert and read any warning signs or markings. Bring them to the attention of coworkers who may have missed them. Encourage communication by accepting repeated information politely. It is better to be notified about the same hazard several times, than not to be notified at all.

If ITS installers discover any defective or damaged equipment or facilities, they must report them promptly to their supervisor or directly to persons qualified to handle the problem (e.g., report damaged electrical power lines to electrical workers on-site or to a building or construction supervisor who will contact electrical workers).

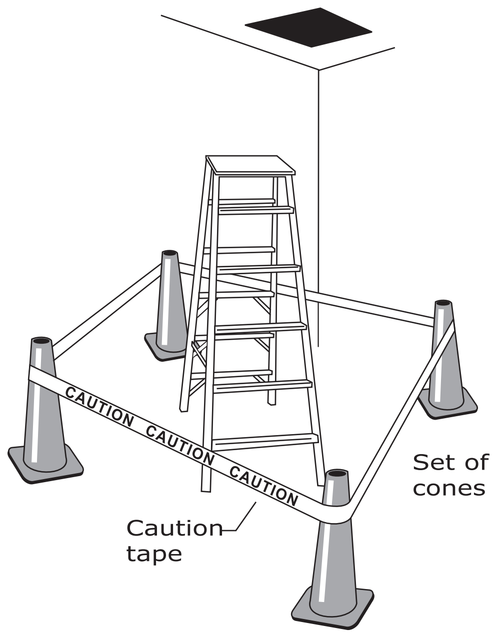
If the defect or damage poses an immediate hazard, the ITS installer should do everything safely possible to ensure that others are not harmed by the hazard before qualified personnel arrive to troubleshoot the problem. This may involve notifying other workers in the area, putting up signs and barriers, or standing guard until qualified personnel arrive.

IMPORTANT: ITS installers must promptly report all accidents or injuries to their employers.

Designating Work Areas

Always use safety cones to designate work areas and to restrict access (see Figure 1.10). Yellow caution tape and folding A-frame signs may be used. Leave enough room inside the cone perimeter to do the required work.

Figure 1.10
Designated work area



Consider the needs of the building occupants whenever possible. Try not to block a doorway or hallway for which there is no alternate route any longer than necessary. When working near doors or hallway corners, try to ensure that oncoming pedestrians can tell there is a work area ahead.

Do not leave open floor systems, open ceiling systems with dangling access panels, or unattended equipment. Do not leave work areas cordoned off longer than required. The customer and coworkers will soon realize the work is complete and start disregarding the warnings. This could cause an accident in the future when a real danger exists.

Carefully follow the manufacturer's instructions when mounting, securing, and using potentially dangerous mechanical equipment for cable pulling (e.g., winches, cable wheels, and cable brakes). Do not set up or operate this equipment without receiving adequate training first.

Tools and Equipment

ITS installers must use only the tools for which they are trained or certified to operate. Manufacturers require users to be certified to use certain devices (e.g., powder-actuated tools). Never be afraid to ask questions or advise that using a specific tool is uncomfortable.

Use the tools only for the purpose for which they are intended (e.g., use a tool designed for stripping to strip cable insulation—not a pocketknife). A screwdriver is not a scrapper, chisel, pry bar, drywall saw, hole punch, or a drill for wood.

Examine both hand tools and power tools regularly to ensure they are in safe working condition. Broken tools must be immediately tagged “broken” and removed from the job site. A detailed description of the problem should accompany the tag. This will prevent an injury to someone using the tool prior to the tool’s repair or replacement.

Wooden or plastic handles of hand tools must be kept free of splinters, sharp-edge cuts, or other surface damage that could injure worker’s hands. Do not use a hand tool if its handle is loose. Loose-handle tools can give way very suddenly, causing injuries to people and damaging equipment.

When using powder-actuated tools, always verify that the area behind the work area is clear.

Do not attempt to drive nails or other fasteners into:

- Brittle or hard materials (e.g., glazed tile, glass block, or face brick). The shattering of the material (i.e., the fastener) can scatter dangerous shards across a wide area.
- Soft or easily penetrated materials. The nails or fastener can pass through the material and create a hazard for people on the other side.

NOTE: These precautions apply to both manual and powder-actuated devices.

Inspect power tools regularly to ensure that automatic cutoff, guards, and other safety devices work properly. Follow the manufacturer’s recommended maintenance schedule to ensure reliable operation.

Before each use, examine power tools to ensure that all guards are in place and securely attached.

Safety codes often require a ground fault circuit interrupter (GFCI) when temporary electrical wiring is used. Temporary electrical wiring may be an extension cord or even a building’s entire internal electrical wiring prior to final inspection and acceptance.

Tools and Equipment, continued

Power tools that require a three-conductor power cable must be grounded. Never use a power tool if the ground prong of the plug has been cut off. Never use a power tool with an extension cord or adapter that eliminates the ground prong before the cord reaches the outlet. Never use a tool's power cord to lift or lower the tool.

Carefully follow all manufacturers' instructions when mounting, securing, and using potentially dangerous mechanical equipment (e.g., tuggers [for cable pulling], tension arms, cable wheels, cable brakes, and powder-actuated guns). Do not set up or operate this equipment without first receiving adequate training and having access to the manufacturers' instructions.

NOTE: Keep original instructions for tools on file at the office. Keep photocopies of the instructions with each tool. This ensures that a set of instructions is always available at the office and used to make additional copies for the job sites.

Ensure adequate lighting is available to safely and efficiently perform work. Proper lighting will help prevent accidents and rework. Use portable lighting and keep it away from combustible materials.

Ladder Safety

ITS installers must know how to choose, securely place, climb, and safely work on a ladder. The location of ITS cabling and equipment requires that ladders be used often for both installation and repair work.

NOTE: The local AHJ often requires that manufacturers print ladder-use guidelines on the ladders. Read and follow these guidelines.

The local AHJ does not always require workers to wear fall-arresting safety equipment while working on portable ladders. However, the local AHJ regulation enforcement at the site level may have unique requirements that add to the requirements set at the national level. Even though it may not be required, it is a good safety practice to belt into a secure anchorage when working aloft with heavy equipment or over a prolonged period.

Use the correct type of ladder. Never use a metal ladder if the ITS installer or the ladder could come in contact with energized electrical cables or equipment. Use ladders made of wood or nonconductive synthetics in these situations. Most construction sites will not allow metal ladders on site for safety and insurance reasons. When working over three steps high, a fixed or mobile scaffold is recommended in place of a ladder.

Ladders should be examined before each use. Check to ensure that:

- Joints between the steps and side rails are tight.
- Antiskid feet are secure and operating properly.
- Moving parts operate freely.
- Rungs are free of dirt, liquids, or other substances that could cause slipping.
- Side rails are not excessively bent or dented.
- The ladder is designed and rated for the height and weight load it will be required to support.

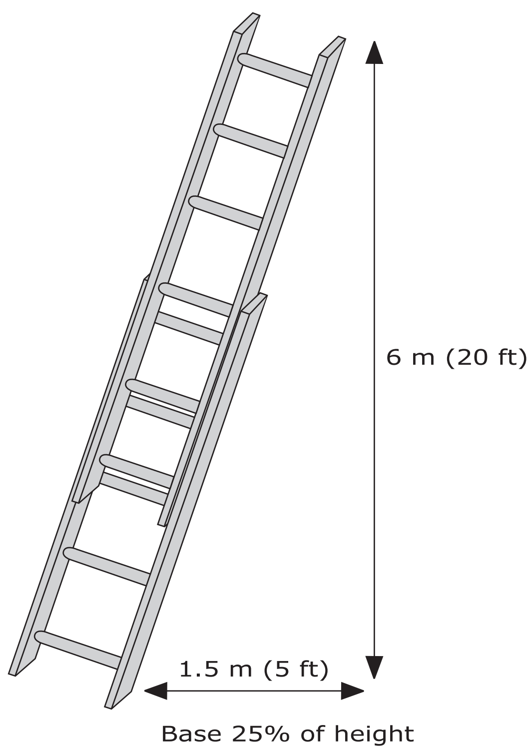
Ladder Safety, continued

Choose a secure location to set up the ladder (e.g., flooring or ground) that is solid and level and offers adequate traction for the ladder's feet. If adequate traction is not available, the ladder must be lashed in place or held in position by other workers. Never set a ladder on top of a box, furniture, or any other unstable surface.

Place an extension ladder so that both side rails are supported at the top. For stepladders, verify that the supports that link the ladder rails to the back rails are fully extended and locked in place.

Verify that the extension ladder is set at the proper pitch (i.e., angle). The distance from the base of the ladder to the supporting wall should be one-quarter (25 percent) of the length of the ladder (e.g., a ladder extended 6 meters [m (20 feet [ft])] up a wall would have its base 1.5 m [5 ft] from the wall). See Figure 1.11.

Figure 1.11
Extension ladder



ft = Foot
m = Meter

Ladder Safety, continued

Extension ladders should always overlap between sections by at least three rungs. The top of the ladder should extend up to the work area and 1 m (3.3 ft) above catwalks or lofts. This allows the ITS installer to easily find the steps when getting back onto the ladder from the catwalk.

Never paint a ladder. Doing so will hide any stress cracks or damage.

Try to place the ladder where it will be out of the traffic's way. Use safety cones to designate a restricted area around the base of the ladder. Never set a ladder in front of a door that opens toward the ladder unless the door is locked or can be blocked or guarded from the other side.

When climbing up or down a ladder, always face it. When using a ladder, never:

- Exceed the ladder's weight rating. Most ladders are designed for one person only.
- Stand on the top two rungs of a ladder.
- Leave any object (e.g., tools, gloves) on any rung of a ladder.
- Straddle a ladder or stand on the rear rungs. The rear rungs are narrower than the front steps and are not designed to support weight.
- Intentionally drop or throw down anything (e.g., tools, excess wire, scraps) when on a ladder. Use a hand line and a grunt sack to raise and lower items.
- Fasten two or more ladders together to create a longer section unless they are specifically designed for such use.
- Move, shift, or extend a ladder while it is in use.

When the job requires a ladder, use a ladder. Do not stand on furniture, boxes, or any other makeshift ladder substitute. If a ladder is broken or stressed, tag it according to company policies with a large "do not use" sign to keep others from becoming injured. Defective equipment should be removed from the job site immediately and returned to the office for repair or disposal.

Personnel Lifts

A personnel lift is required when a ladder or scaffold cannot be used safely or is impractical because of the required working height or weight of personnel and equipment or customer requirements.

Two types of lifts are:

- Bucket lift—This is a fiberglass bucket mounted on the end of an extendable arm in which the user stands. The articulating arm allows the user to approach the work area from several angles and to avoid obstacles and possible safety hazards. These units are usually large and can be used in limited areas.
- Scissor lift—This is a working platform mounted on a large scissor jack. The scissor lift is very stable but not very flexible in its use. As the scissors are extended, the platform moves straight upward. If there are any obstacles above it, the platform is unable to maneuver around them.

NOTE: BICSI recommends the user be properly trained and certified in the use of lifts.

Factors that determine whether a lift is suitable include:

- Maximum working height of the lift.
- Size of the work area.
- Obstacles that may obstruct the lift.

Setting brakes and using stabilizing legs or outriggers, if equipped, must secure lifts. Personnel must follow the safety requirements for fall-arresting personal protection devices described later in this chapter.

NOTE: Clients may require specific types of powering for the lifts dependent upon working environments (e.g., electrical, fuel, mechanical).

Personal Protective Equipment (PPE)

Overview

Personal protective equipment (PPE) is safety equipment worn by the ITS installer. When used correctly, PPE greatly decreases the risk of injury. When it is used incorrectly—or not used—it can leave the ITS installer exposed to a wide variety of dangers.

The PPE that an ITS installer is required to wear when performing a task depends on:

- Hazards of the task.
- Hazards at the work site.
- Local, state, and national safety requirements.

PPE must fit well and be comfortable. Equipment that fits properly and comfortably ensures that the ITS installer and the protective equipment can work at the same time.

Pay careful attention to the training for each item of PPE. Learn:

- When the equipment must be used.
- How to put on, adjust, and take off the equipment.
- What the equipment can and cannot protect against.
- Care and maintenance of the equipment.

It is important to inspect PPE each time it is used. Look for wear, cracks, tears, punctures, weak joints, or other signs that the equipment may not be capable of providing protection. Report any problems to the proper supervisor. Never use defective protective equipment.

Remember that no amount of protective equipment can provide complete protection. Often the best personal protection comes from using caution, proper procedures, and common sense when working.

Headgear

ITS installers must wear protective headgear (hard hats) when working in any area where there is danger from:

- Falling or flying objects.
- Electric shock.
- A blow to the head.

Generally, the hard hats provided for ITS installers afford both physical and electrical protection. ITS installers should ensure that their hard hats provide electrical protection before working around power lines or equipment. The hard hat must fit securely enough to ensure that it will not slip and block the ITS installer's vision or fall on the equipment the ITS installer is working on. ITS installers may choose to use a chinstrap to secure the hard hat only if the chinstrap is thin enough to give very easily if the hard hat catches on something during a fall.

Headgear, continued

Before putting the headgear on, inspect it for cracks, weakness of the internal support structure, or other defects. The date of manufacture appears stamped on the underside of each hat's brim. The date allows easy identification if a certain run of hats has to be recalled for defect. Hard hats typically have up to a five-year life span if not subjected to abuse. ITS installers must wear properly rated hard hats.

Replace hard hats that show signs of scratches and cracking or if a shiny surface appears dull or chalky. Do not place stickers on hard hats because they may hide defects, or their adhesive may react chemically and weaken the hat.

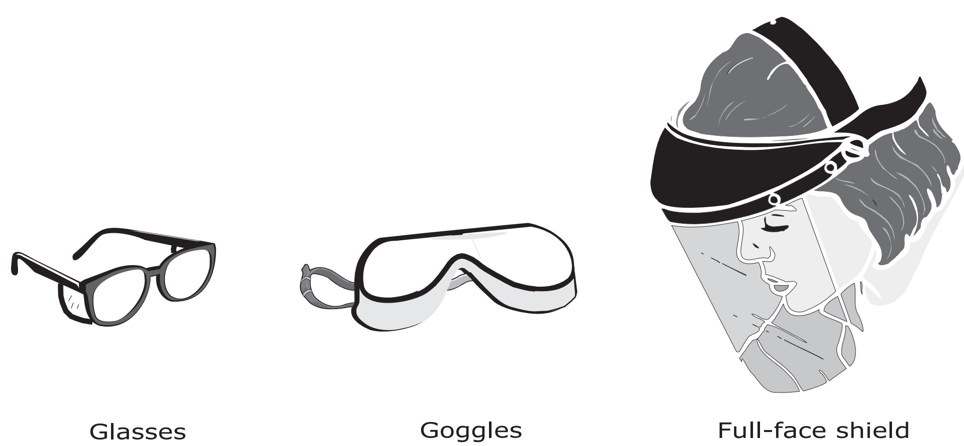
Eye Protection

ITS installers must wear eye protection (e.g., glasses, goggles, or full-face shield). See Figure 1.12. If the ITS installer must wear vision-correcting prescription glasses, prescription safety glasses with side shields may be required or goggles that fit over personal prescription glasses can be used. All eye and face protection must meet or exceed local AHJ requirements.

A wide variety of work situations require eye protection, including:

- Working with batteries (i.e., requires wearing a full-face shield if there is danger of splashing chemicals).
- Using powder-actuated tools.
- Working with optical fibers.
- Any situation in which the ITS installer is working above eye level and looking up at the work.

Figure 1.12
Eye protection



Wear protective goggles or glasses that provide side protection as well as front protection when the hazards involve flying objects. ITS installers who wear prescription lenses must have eye protection that either fits over the prescription lenses or includes the prescription in the protective lenses.

Breathing Protection

ITS installers must wear a respirator or filter mask whenever harmful dust, gas, smoke, chemical vapor, or other pollutant is present at the work site.

Never work without the proper breathing protection. The effects of breathing some harmful substances may not show up until hours, weeks, or years after the exposure.

Filter masks are used in cases where the atmosphere is moderately hazardous. Very hazardous atmospheres require the use of protective masks or positive pressure self-contained breathing apparatus (SCBA).

To provide appropriate protection, each mask must seal itself to the user's face. This may require removal of facial hair.

NOTE: Several chemical manufacturing plants and other industrial sites will not allow personnel with excess facial hair (e.g., heavy beards) to work on site.

ITS installers should not try to work while wearing a breathing protection device unless the:

- ITS installers have been fully trained to use the device.
- Device has been carefully fitted.
- ITS installers have been found physically fit to work while wearing the device.
- Device is designed for the specific breathing hazard or chemical to which it may be exposed.

Although employers are required to inspect and maintain breathing protection devices, the ITS installer should inspect the device every time it is used. Report any problems to the supervisor in charge of breathing protection devices.

Lifting Belt

A lifting belt does not give the user any added strength. The belt does help to support the stomach muscles while encouraging good posture. It should be noted, however, that these belts might also give wearers a false sense of security. These belts do not enable wearers to lift heavy objects with a decreased chance of injury.

Use correct lifting techniques when lifting any object on the job. The following guidelines should be followed:

- Never bend to pick up a heavy object. This is the most frequent cause of back injury and strain.
- Lift with the legs, not with your back. Keeping your chin up helps to keep the back straight.
- Turn with your feet and not at the waist.
- If possible, wear a lifting belt when lifting or moving heavy objects or equipment.

Lifting Belt, continued

When carrying or moving items, always know the path to the destination point and ensure the items do not block your vision.

A safe rule for supervisors to follow is to restrict lifting of loads to about 25 kilograms (kg [55 pounds (lb)]) per person. If heavier materials need to be moved, two ITS installers should provide assistance or use appropriate lifting machinery.

Most government contracts in the United States require that workers wear lifting belts.

Protective Footwear

Wear protective footwear on work sites where feet could be injured by falling objects, rolling carts, or stepping on sharp objects. A suitable pair of shoes will protect feet from injury and fatigue.

Metallic or nonmetallic toes will help protect toes, while metallic or nonmetallic shanks will offer protection from stepping on sharp objects. Metallic or nonmetallic shanks help distribute weight across the base of the shoe. This reduces foot fatigue while standing on the thin rungs of an extension ladder. Leather-sole shoes are not advisable because leather conducts electricity when wet.

Check with the AHJ for the approved standard of protection footwear is to comply with.

Gloves

Wear protective gloves when performing any work that has the potential for hand or forearm injuries.

- Leather gloves provide protection from cuts, abrasions, and extreme temperatures.
- Rubber, plastic, or latex gloves provide protection from harmful chemicals.

NOTE: Rubber and leather gloves are not for high-voltage use. All high-voltage situations should be referred to qualified persons.

Detection Badges/Exposure Monitors

Some work sites may require that ITS installers wear detection badges or use monitors to ensure the exposure to a hazardous substance does not exceed safe levels. Understand how the badge or monitor works before entering the hazardous area.

Some monitors or badges will provide real-time feedback; they show actual exposure levels as they happen. They may change colors or have a dark stripe that gets longer with the amount of exposure.

Other types will only absorb the toxins at the same level the ITS installer is being exposed to them. These need to be inserted into a scanner to determine the amount of exposure. It is extremely important to check these types of monitors frequently to limit the ITS installer's exposure levels.

Always observe time limits specified for working in a hazardous environment.

High Visibility Vest or Jacket

On most construction sites, a high visibility vest or jacket is required.

Hearing Protection

Hearing loss is one of the most frequent injuries encountered in the construction trades. The injured person does not feel pain, but after years of exposure to high levels of construction noise, varying frequencies of their hearing may be lost.

Wear hearing protection while working near loud noises. Even the sound of a hammer striking a metal clamp onto red iron requires hearing protection. If the ITS installer experiences a ringing in the ears, adequate hearing protection has not been used.

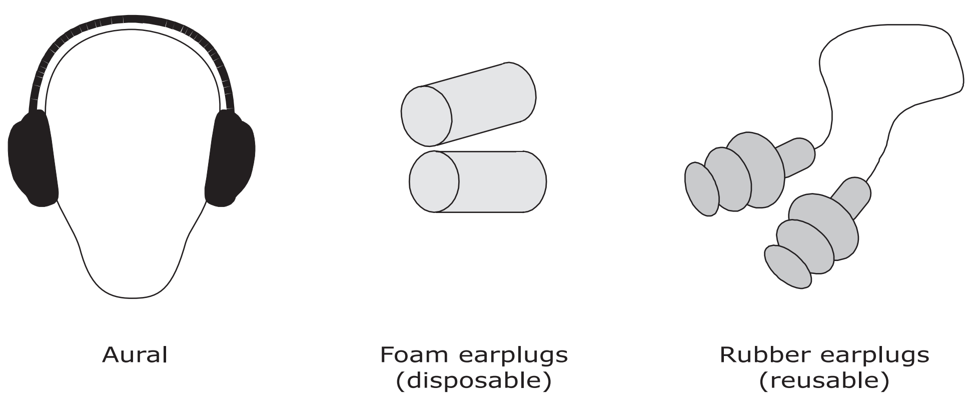
There are three major types of hearing protection (see Figure 1.13):

- Aural—These plugs resemble earmuffs. They are available in passive or active models. When wearing the active models, normal conversation can be heard; however, when a loud noise occurs, the protection automatically dampens the louder sound.
- Foam earplugs (disposable)—These plugs can be rolled between the fingers and slipped into the ear canal.
- Rubber earplugs (reusable)—These may be on a breakaway cord or individually housed in a pocket-sized plastic container. These are convenient because they can be attached to a hard hat or around the ITS installer's neck and tucked inside the ITS installer's shirt. It is vital that they be on a breakaway cord to prevent strangling.

Certain sites require specific types of hearing protection. Check with your local AHJ for further information.

When working in a noisy work site (with or without earplugs), do not rely on hearing to detect the location of machinery, coworkers, or other hazards.

Figure 1.13
Hearing protection



Safety Harness

ITS installers use elevating devices (e.g., scissor lift, bucket lift) to reach their work location when ladders are impractical due to height or weight requirements.

To prevent falls, ITS installers must wear a full body harness and one lanyard any time they use an elevating device that does not afford an approved barrier that completely surrounds them or if the barrier is to be opened while elevated. No fall protection device is required when the lifting device is equipped with an approved barrier surrounding the user. Only those barrier systems provided by the lifting equipment manufacturer are approved.

NOTE: The sides of a bucket lift do not typically meet the requirements of a safety barrier because the bucket can tilt and may not provide a stable platform. Bucket lifts usually require a full body harness with one lanyard attached to the lift.

The use of a full body harness and two lanyards is required whenever the ITS installer leaves the safety of the elevating device or is using catwalks (see Table 1.4). Using two lanyards allows the wearer to always have one lanyard attached to a safe support. If the users have to move along a catwalk but run into an obstacle, they can simply attach their second lanyard beyond the obstacles prior to disconnecting the first one, allowing them to be safely attached to the structure at all times.

Safety lanyards are available as simple nylon ropes with self-closing and locking keepers (metal safety hooks) on each end, or they can incorporate a shock absorber into the line. If a fall were to happen, the shock absorber would reduce the force of the sudden stop to the injured person.

Table 1.4
Harness specifications

Lift Usage Description	Full Body Harness Required	Number of Required Lanyards
Fully enclosed safety barrier	No	None
Open or no surrounding barrier	Yes	One
Leaving lift	Yes	Two (for 100% contact)

Safety Harness, continued

BICSI does not recommend the use of safety belts and lanyards equipped with the nonlocking type of self-closing keepers (metal clips) within buildings and other types of structures.

Many work sites do not allow the use of safety belts. They do not provide the same level of protection as the full body harness and may cause back injuries.

Before ascending or descending:

- Inspect the harness and its hardware carefully for signs of wear or damage.
- Ensure that the harness is properly secured to the elevating device's anchoring point and never to the supporting guardrail or platform.

Whenever securing the lanyard, always check the connection. The ITS installer must ensure the metal clip has captured the lanyard's rope or the equipment's safety ring, and that it is securely fastened.

Clothing

Work clothing should be reasonably snug but must allow the ITS installer to move freely. Do not wear dangling or floppy clothing that may get caught on tools or surroundings. Keep shirttails tucked in and cuffs (if any) buttoned or neatly rolled up. This is especially important when the ITS installer is working in a confined space, on an elevating device, or near operating machinery.

Clothing made of cotton is typically more comfortable and safer than synthetic materials that could melt to the worker's skin in the event of a fire.

Do not wear metal jewelry or metal watchbands when working on ITS circuits or equipment. Field-damaged clothing shall be repaired immediately, or the individual must leave the job site. Duct tape may be used to temporarily mend torn clothing.

Grooming

Long hair can be extremely dangerous when working around operating machinery and working aloft. Hair can easily be pulled into machinery or become caught on ceiling grids. Pulling the hair back in a ponytail usually provides adequate protection while allowing the worker to wear safety equipment.

NOTE: The safest way to ensure that hair does not get caught on something is to completely tuck it under a hat.

Hazardous Environments—Indoor

Overview

Although there are hazards involved in any ITS cabling installation work, some indoor situations are especially hazardous. These situations require extra safety precautions and often extra protective equipment.

A complete study of hazardous indoor environments is beyond the scope of this manual. The following sections give a brief overview of several hazardous environments and some of the extra precautions they require.

Always carefully follow all safety procedures when working in an indoor hazardous environment.

Electrical Hazards

The presence of electrical power cabling and electrical equipment is probably the most common environmental hazard faced by ITS installers. Like ITS cables, electrical power cables run in walls, under floors, and over ceilings. Power is required for ITS equipment in telecommunications rooms (TRs) and equipment rooms (ERs).

All electrical systems are potential killers; therefore, all personnel should be aware of the dangers and have electrical safety training. Use power tools and equipment only for the purposes for which they are made. Use tools only according to the manufacturers' instructions.

Wear rubber-sole shoes and remove all metallic jewelry. Most jewelry is made of gold or silver, which are extremely good conductors of electricity.

Never intentionally expose yourself to an electrical shock (e.g., do not run your finger down a termination block to check for ringing current).

Physical effects of current (in milliampere [mA]) are as follows:

- 2 to 3 mA produce a tingling of the skin.
- 10 mA produce a painful shock and the muscles cannot release the contact.
- 50 to 100 mA cause breathing to become difficult.
- 100 mA triggers ventricular fibrillation, which causes the heart to repeatedly relax and violently clamp shut. This occurrence severely damages the heart and usually results in death.
- 200 mA and above cause the heart to clamp shut and severe burns occur on skin and hair. At this level, the damage to the heart may actually be smaller than at 100 mA, allowing the injured person a better chance of survival if medical treatment is given on time.

Electrical Hazards, continued

Treat all electrical circuits as if they were live (energized). Even after the circuits have been turned off and tested to ensure that they are off, treat electrical circuits as if they were likely to become live again at any moment. Always lock out and tag all electrical circuits that have been turned off. Continue to maintain appropriate clearances, wear the proper PPE, and take the recommended precautions.

ITS installers must be especially careful in situations where electrical circuits or equipment may be contacted blindly (e.g., drilling into walls and fishing conduits).

WARNING: Never use a metal fish tape in a conduit if the exit point is unknown.

Avoid working in standing water. If ITS installers must work in standing water (e.g., in a basement tunnel), take extra care to ensure that no electrical power circuits are near the water or the work area.

Never cut the ground prong off a power tool plug. Removing the ground prong creates a serious possibility of severe electrical shock for the worker using the tool.

Avoid working on energized equipment. If the ITS installer must work on an energized circuit (e.g., performing an alignment in a microwave radio or troubleshooting a telephone system), have a qualified safety person standing by.

All technicians must know:

- Where and how to secure electrical circuits.
- First aid and CPR.
- Where and how to get help.

Many ERs are outfitted with an emergency electrical safety board. This board is mounted to the wall and may have a:

- First aid kit.
- Static grounding wrist strap—This is used to take the built-up static charge from the ITS installer to the ground and avoid damaging sensitive circuits.
- Safety grounding wand—This is an insulated handle with a metal tip. It is connected to an insulated cable with a large metal clip on the opposite end. The clip is connected first to a ground source. The metal tip is used to short any transient voltages left on a de-energized circuit.
- Pair of high-voltage rubber gloves and protective leather outer shells—The rubber gloves should be inspected regularly for holes and cracks, while the leather outer shell must show no signs of wear. Only ITS installers trained in high-voltage rescues should use these gloves.
- Wooden cane—The cane should be lacquer free in order to be a nonconductive rescue device. It may be used to pull live wires off an injured person or pull the injured person to safety.

Electrical Hazards, continued

In the case of an electrical fire, it is most important to protect people. Protection involves four steps easily remembered by an acronym RACE, which stands for:

- Rescue—Get people out of danger.
- Alarm—Sound the alarm, call for help.
- Confine—De-energize all electrical circuits involved with the fire. Close windows and doors and deactivate the heating, ventilating, and air conditioning (HVAC) system.
- Extinguish—Control the fire with the correct type of firefighting equipment. All TRs and ERs should have access to a fire extinguisher designed to fight an electrical fire.

When working in TRs, make it a habit to check for an approved fire extinguisher. Extinguishers may be designed for:

- Combustibles (e.g., paper, wood, or anything that leaves ashes).
- Liquids (e.g., gas, oil, or alcohol).
- Electrical fires.
- Metal fires (e.g., magnesium fires).

The extinguishers used shall be compliant with the classifications or categorizations dictated by the AHJ.

These designations are important since using the wrong rating could electrocute the user or possibly spread the fire (e.g., spraying water into a grease fire).

Lightning Hazards

Although lightning is generally thought of as an outside plant (OSP) hazard, it can endanger indoor workers. This is especially true during construction or renovation, when protective systems may be incomplete or disconnected. Exercise caution during an electrical storm when working on premises cables that are electrically connected to OSP cables.

Access Floors

Raised computer room flooring is becoming very popular in ERs. There are potential dangers associated with access flooring:

- Floors are usually part of the HVAC distribution system. When a floor tile is removed, pressure is released, and dirt, dust, and debris may fly at the ITS installer. Safety glasses are necessary and a filter mask is suggested.
- Floor systems are usually constructed with metal pedestals interconnected with stabilizing stringers joining them. The floor tiles are then placed on top so each pedestal will support the intersection of four separate tile corners. These systems are very stable, even with several tiles removed.

  Another construction method is without the stringers. The floor maintains its stability when all the tiles are in place. Never remove all the tiles in a single row if stringers are not used for stability. If stability shifts toward the open row where the tiles have been removed, the entire floor may collapse.
- When tiles are replaced, it is often like a jigsaw puzzle. If the tiles are not placed exactly in the same spot, the floor will often have loose tiles that wobble when walked on.
- When working in a live communications space where an access floor is installed, permissions will be needed to remove tiles as they may affect the fire and smoke detection system.

NOTE: Prior to removing tiles, put a piece of tape in the corner of every tile to be removed. Place the tape in the same corner of each tile (e.g., northeast corner) and put a unique number on the tape. This ensures that the tiles will go back exactly as they came out.

Catwalk Hazards

In large buildings or industrial facilities, a catwalk may be provided to help workers reach utilities. When working from a catwalk, stay on the catwalk. Do not climb or walk onto beams or other support structures.

Never intentionally drop or throw anything (e.g., tools, excess wire, scraps) from a catwalk or other elevated work location. Raise and lower equipment with a hand line and tool bucket or bag.

Crawl Space Hazards

ITS cabling often runs over suspended ceilings, below raised floors, and in other spaces where ITS installers cannot stand upright. These areas are called crawl spaces.

It is a good idea to wear protective headgear (e.g., hard hat) when working in crawl spaces, especially when electrical wiring is present. The hard hat will protect the ITS installer's head from the hard surfaces and sharp edges that may be found on the supporting hardware for the floor or ceiling system.

Ensure that lighting is adequate to see the work clearly. If not, use a flashlight or other work light for extra light.

Before beginning work in any crawl space, take the time to locate and identify other facilities that are routed through the crawl space (e.g., electrical power wiring, pipes, HVAC ducts). Identifying surrounding hazards can keep ITS installers from accidentally damaging another system or endangering themselves.

A filter mask or other breathing protection may be required if dust, fibrous insulation, or other breathing hazards are present in the crawl space. Check with employers and the building management to determine the nature of the hazard and the protection required.

When moving through a crawl space, walk or crawl only on surfaces designated to support walking or crawling. The ITS installer should never put weight on the ceiling support hardware that is not designed to support crawling or walking. Before putting full weight on a walk or crawl surface, the ITS installer should ensure that the surface is strong enough to bear weight. Never put weight on cable support devices (e.g., cable trays).

Never intentionally drop or throw anything (e.g., tools, excess wire, scraps) from a crawl space above a suspended ceiling. Do not drop, place, or throw anything on top of the ceiling tiles.

Crawl spaces may be considered confined spaces that require additional precautions (e.g., venting).

NOTE: See Confined Spaces in this section for more information.

Confined Spaces

Working in confined spaces poses additional safety risks. Comply with applicable codes, standards, and regulations associated with confined spaces.

A confined space:

- Is large enough and so configured that an employee can bodily enter and perform assigned work.
- Has limited or restrictive means for entry or exit (e.g., tanks, vessels, silos, storage bins, hoppers, vaults, pits).
- Is not designed for continuous employee occupancy.

Maintenance holes (MHs), cable vaults, crawl spaces, and attics can fall under the definition of a confined space.

Confined spaces may require testing for a hazardous atmosphere because they may contain:

- Unsafe oxygen levels below 19.5 or above 23.5 percent.
- Flammable gas, vapor, or mist.
- Combustible dust.
- Any toxic substance in a concentration greater than deemed safe by safety standards. Nonlethal or incapacitating toxins are not covered by this provision.
- Any other atmospheric condition that is immediately dangerous to life or health.

When toxins, gases, or combustibles are detected, the ITS installer shall:

- Provide continuous forced air ventilation to purge the contaminants from the space.
- Periodically monitor the air quality within the space.
- Evacuate the space immediately if contaminants return.
- Determine why the contaminants returned and take corrective action prior to re-entering the space.

Certain confined spaces may require:

- Breathing apparatus.
- Protective clothing.
- A trained safety person stationed outside the space.
- A lifeline attached to the worker inside the space.

Hazards from toxic or flammable gas are rare when working inside a building. TRs and ERs should be completely free of gas hazards. However, there may be some situations where a sealed vault-type structure (e.g., an entry facility or splice pit) may accumulate gases.

Always use caution when entering any room or work area that is marked with warning signs that prohibit open flames or indicate other potential gas hazards.

When opening a vault-type structure, treat the vault like a MH. Before entering the vault, use a gas detector to determine whether any dangerous gases are present. If dangerous gases are present, the gases must be cleared from the vault before any worker enters it. Testing vaults and MHs for gases are usually OSP procedures and are outside the scope of this manual.

Optical Fiber Hazards

Optical fiber systems involve some hazards that copper cabling systems do not. Most of these different hazards involve the optical fiber glass or the transmission light source.

When performing any installation, splicing or termination process including installing connectors or splicing optical fiber cable cutting, due to the nature of the optical fiber, there will be optical fiber glass shards or short pieces of optical fiber that need to be handled and disposed of properly. Optical fiber glass is not considered hazardous waste; however, there are recommended best practices for its disposal.

The ITS installer should have a designated container fitted with a removable secure lid to store these pieces of optical fiber glass. The container should be labeled properly. When it is full, the closed container should be disposed of in an approved manner. A soft drink can or plastic cup is not acceptable for this purpose. Electrical tape or masking tape formed into a loop with the sticky side out is also not an acceptable method of disposing of optical fiber ends.

Using a short piece of tape to pick up a small piece of optical fiber from a work surface is acceptable as long as the ITS installer is careful not to apply pressure so that the shards of glass penetrate the tape and cause injury. Eating and drinking is also not permitted in the work area as optical fiber glass may be ingested by the ITS installer.

Never throw bare fiber scraps into community trash containers. Always seal fiber scraps in a container. Tape the container closed and mark it as optical fiber glass scraps. Take the container directly to the dumpster to avoid accidents to the unsuspecting customer.

WARNING: Never look into the end of an optical fiber cable. Most optical fiber transmission light is invisible but can burn the retina of the eye before the ITS installer realizes that the light is present. Light sources for test equipment may be just as hazardous as the regular system light source.

Always wear eye protection when handling exposed fibers. Small fragments of optical fiber can easily fly into the eyes during cleaving. Exposed fiber ends can injure the eyes when cables twist, flip, or fall.

Optical fiber termination kits may contain chemicals (e.g., epoxy or alcohol) that are subject to chemical hazards. Material safety data sheets must be readily available on the job site.

NOTE: See Chemical Hazards in this section for more information.

Battery Hazards

Working with or around vented lead-acid (wet) cell or nickel cadmium (NiCd) batteries requires:

- An eyewash station.
- Training in handling electrolytes.
- Full-face shield protection.
- Acid-resistant gloves and apron.
- Training in emergency procedures for spills.

Always use care when working around batteries. Batteries are always live. Lead-acid batteries release hydrogen and oxygen gases as they are charged. Hydrogen is extremely combustible and must be vented outdoors. Most batteries are vented into the room and an exhaust fan pulls the hydrogen and oxygen outdoors. If the fan fails to operate, the gases will build up and create a potential hazard.

Neutralize small acid spills with sodium bicarbonate (baking soda) and clean up with damp rags.

Flush electrolyte burns to the skin with large quantities of fresh water. Do not attempt to neutralize acid burns to the skin with sodium bicarbonate, as this will cause further injury. Seek immediate medical attention.

Asbestos Hazards

Asbestos is a fibrous mineral substance that was used in many buildings as an insulation material between the mid-1940s and 1978. Asbestos was widely used in acoustical ceilings, wall and ceiling insulation, fireproofing for structural steel, and pipe and boiler wrapping.

Asbestos often looks like plaster and cloth tape wrapped around pipes or an expanding insulation that is sprayed on boilers and structural steel. The difficult part of identifying asbestos is that it resembles other forms of insulation and must be checked in a laboratory.

Breathing asbestos fibers can cause cancer of the lungs, stomach, colon, esophagus, and other organs.

Schools and other public institutions were required to locate asbestos-containing materials in their buildings and determine the threat they posed. The asbestos-containing materials were then either:

- Removed.
- Cleaned and sealed to prevent fiber releases.
- Labeled as asbestos and left intact.

Asbestos Hazards, continued

The mere presence of an asbestos-containing substance is not hazardous as long as it is not releasing fibers into the air. However, disturbing a substance that contains asbestos by sawing, drilling, breaking, or rubbing may cause it to release fibers and create a serious breathing hazard.

Laboratory tests are required to determine whether a substance contains asbestos. Building managers and owners are required to maintain records of any known or suspected asbestos-containing substances in their buildings.

If ITS installers encounter a labeled asbestos-containing substance and cannot perform the job without disturbing it, they should stop work immediately and consult their employer about alternative plans.

Chemical Hazards

Many products used in the ITS industry contain chemicals that can be hazardous to people and the environment. To help the ITS installer work safely with commercial products, chemical manufacturers are required to provide material safety data sheets and employers are required to provide access to them.

Material safety data sheets are provided for all products used in a commercial environment that can be absorbed through the skin, inhaled, ingested, or require special handling for disposal.

Material safety data sheets must be readily available at the job site where the products are being used. They may be indexed and retained in a three-ring binder at the work site, or they may be made available electronically, as long as there is a backup method of accessing the material in the event of an equipment failure. The company must identify the person responsible for obtaining and updating the material safety data sheets on a regular basis.

Each material safety data sheet must contain, and all employees should be aware of, the following information regarding the product:

- Health hazards, including warning signs and physical symptoms.
- Physical characteristics of the hazard (e.g., vapors, flash point, skin contact).
- Permissible exposure limit.
- General procedures and precautions for safe handling and use of the product.
- Applicable control measures.
- First aid and emergency procedures.
- Identification of the responsible manufacturer.

Chemical Hazards, continued

Chemicals and chemical vapors can be very dangerous. Without proper handling and ventilation:

- Toxic vapors can overwhelm the user, causing immediate and long-term effects. Fumes may cause nausea, headache, or vomiting. Prolonged exposure can cause disease to internal organs.
- Vapors may be flammable and create a fire when exposed to a spark.
- Vapors may be explosive when concentrated in a confined space.

When working with products that produce toxic or flammable vapors, it is always best to use them outdoors. When this is not practical:

- Notify other workers and have a safety person check the area periodically.
- Open windows.
- Restrict air flows to other areas where people are working.
- Blow toxic air directly outdoors, paying attention not to send the vapors into an unsuspecting office next door.
- Blow fresh air into the work area.
- Take frequent breaks to keep the levels of toxins low.

Other Hazardous Locations

Some job sites are considered hazardous regardless of the work actually undertaken. Working around electrical equipment is considered hazardous, and ITS installers must be current on their knowledge of safety in that environment.

Other sites considered hazardous by some jurisdictions include:

- Aircraft hangers and other structures in which any part of an aircraft might undergo service or repairs.
- Bulk storage plants (i.e., flammable liquids).
- Grain shipping facilities (i.e., combustible dusts).
- Milling plants (i.e., fibers or other airborne material).
- Portions of hospitals (i.e., gases or bacteria).
- Chemical plants and refineries.

Each of these facilities, as well as several others, has very specific safety rules of which the ITS installer must be aware. It is not enough to be simply careful; the ITS installer must obtain specific direction and training when working in such areas.

Hazardous Environments—Outdoor

Outside Plant (OSP)

Hazardous outdoor working environments (e.g., maintenance holes [MHs], tunnels, ditches, aerial facilities) are outside the scope of this manual. Special OSP training is required for working in these environments. Refer to BICSI's current *OSP Design Reference Manual* (*OSPDRM*) for further information.

Safety Planning

Overview

Most large companies have established safety plans and training following federal and/or state guidelines. However, many small firms have not. Some rely on materials provided by general contractors or specific industry organizations.

Although it is not the intent of this manual to provide any formal safety plan, this section of the manual provides an overview of what such a plan should contain, identifies sources for this information, and includes a sample checklist for safety practices.

The following are the major elements of an effective program.

Management Commitment and Employee Involvement

The employees generally will not fully implement a program not actively supported by management. Conversely, without the support of every employee, even a good plan is doomed to fail.

At a minimum, the following actions are needed:

- Clearly state the company policy on health and safety.
- Establish a clear goal for the program.
- Provide visible top management support.
- Encourage employee participation.
- Provide adequate authority and resources.
- Hold everyone accountable.
- Review and update the program.

Work Site Analysis

Each work site must be examined to identify existing and potential hazards and to anticipate and prevent problems.

The following measures are recommended:

- Conduct baseline work site surveys.
- Analyze planned and new facilities.
- Perform routine hazard analyses.
- Conduct risk assessments on workers' tasks.
- Conduct regular inspections of the site.
- Provide a reliable system of problem notification.
- Investigate accidents and incidents promptly.
- Analyze trends over time to detect patterns.

Hazard Prevention and Control

The goal is to minimize hazards in the workplace.

To accomplish this, the following procedures must be in place:

- Utilize specific safety-defined engineering job techniques.
- Follow safe work practices through training and enforcement.
- Use personal protective equipment.
- Maintain the site in a manner that reduces risk.
- Plan and prepare for problems.
- Know the location of first aid facilities.

Health and Safety Training

Training is a major portion of any effective program and must include the following components:

- Employee training
- Supervisory training
- Management support

An example of a job-site inspection checklist is included at the end of this section.

Example of a Job-Site Inspection Checklist

ITS Job-Site General Inspection

Company Name: ____

Job-Site Address: ____

Superintendent: ____

Date and Time: ____

Inspector(s): ____

Date	Yes	No	N/A	Correct	Area/Issue Inspected
					1. Project site safety analysis complete?
					2. Hazardous materials identified and planned for or removed from site?
					3. Safety activities and protective equipment identified?
					4. Site emergency response and evacuation plan prepared?
					5. Monitoring plan prepared?
					6. Subcontractor conformance accepted?
					7. Employee and manager training completed?
					8. Posters, barricades, and safety signs in place?
					9. Safety meetings scheduled?
					10. First aid kit stocked and available?
					11. Emergency contract telephone numbers displayed?
					12. Emergency communications in place?
					13. Site safety supervisor assigned?
					14. Site recordkeeping system in place?
					15. Adequate toilets and washing facilities provided?
					16. Adequate work area illumination provided?
					17. Electrical service and grounding adequate?
					18. Support equipment (e.g., ladders, lifts, lights, hand tools) checked and serviceable?
					19. Work site cleaned daily?

NOTE: This general safety inspection checklist is not designed to supersede existing safety inspection checklists. It should be used only as a general guideline.

Professionalism

Overview

The information transport systems (ITS) installer works in a world that is constantly changing and developing. For this reason, the ITS installer is required to work with different types of people—on both small and large installations—offering the same quality, professionalism, and acceptable costs.

Technical Expertise

The technical nature of the project requires the ITS installer to be highly qualified and capable of maintaining the system as designed.

Requirements of the industry demand that the ITS installer be a highly skilled professional, a team member, and an ongoing learner.

The ITS installer's role is affected by:

- Current and future technology.
- Complex equipment.
- Advanced tools.
- Constant refining of standards.
- International, national, regional, and local codes.
- Intricate and/or evolving designs.

Project Objectives

Information should be provided about the job location and work area, customer requirements, project schedule, materials, safety issues, and code requirements.

The ITS installer is responsible for knowing the:

- Background of the project and project relationships.
- Project milestones.
- Specific role within the project.
- Specific tasks expected to be performed.
- Challenges and issues unique to the project.
- Methods and techniques planned to be used.
- Applicable standards (e.g., local, state, national, company's, and customer's).
- Security requirements.
- Safety requirements.
- Evaluation of work process.
- Recordkeeping process and requirements.
- Status and monitoring processes, both company's and customer's.
- Required meetings.

Project Team Members

An ITS installer is part of a team. The full team consists of their company and organization, as well as the people and organizations for whom and with whom they work.

An ITS installer may be required to talk and work with many different people:

- Consultants
- Supervisors
- Project managers
- Coworkers
- Customers
- Manufacturers
- Vendors
- Suppliers
- Administrative and clerical staff
- Regulatory and government staff
- Other trades

Team Member Responsibilities

Team membership has its own set of requirements. The ITS installer must take responsibility to know, understand, and communicate all aspects of the job.

This involves getting and receiving information and asking the right questions, such as:

- What is expected?
- What is the project environment?
- What is the expected schedule?
- What are the critical time frames and why?
- What other projects are being installed simultaneously during the project that may impact this project?
- Why was a particular ITS installer chosen for this job?
- Is the ITS installer expected to contribute a particular skill, knowledge, or task?
- What new skills might the ITS installer acquire?
- Is the ITS installer expected to provide training?

The items listed above are important when dealing with both large and small projects. On a small project, the ITS installer must possess high technical and interpersonal skills because there is more interaction with the customer in a shorter period of time.

Interpersonal Skills and Communication Requirements

The ability to plan, organize, work in a team environment, and communicate effectively is just as important as the actual cabling installation performance.

Effective Communication Skills

The ITS installer's role is impacted by the effectiveness of the communications received and the communications delivered, whether verbal or written.

As an effective communicator, the ITS installer should:

- Listen attentively and take notes as appropriate.
- Provide complete information about the project.
- Respect the values, traditions, and beliefs of others.
- Always find at least one positive thing to say.
- Praise in public but correct in private.
- Seek understanding of others.

Each person involved in the project expects all communications to be:

- Timely.
- Clear.
- Concise.
- Unbiased.
- Truthful.
- Free from unacceptable language.

Interpersonal Skills and Communication Requirements, continued

Table 1.5 lists possible members of a project team and describes the types of procedures and issues the ITS installer may need to communicate to each.

Table 1.5
Project communications

Position	Required Communications
Consultant	Design issues.
Supervisors and coworkers	Safety issues, pull methods and techniques, cable tests, work responsibility clarification.
Customers and/or project managers	Project schedules, test results, safety and security issues, progress reports, and potential problems or delays. May include cutover issues, access requirements, and clarification of requirements.
Contractor	Coordination of schedules, blueprints, building access, storage, and required meetings.
Manufacturers, vendors, and suppliers	Project supplies, delivery schedules, verification of specifications, tools, materials, and equipment requirements.
Administrative	Job location, ordering and delivery of clerical staff materials, and work schedule.
Other trades	Work area arrangements, schedules, and safety issues. Work coordination (e.g., grounding, space in closets, and shared pathway space).
Regulatory and government staff	Permits and inspections, regulations and codes clarification.

Customer Relations

After considering the technical aspects of the project, it is important to deal with the relationship the ITS installer will establish with the customer. This is one of the most difficult factors, especially if the person concerned is not trained in interpersonal relationships.

The majority of client loss occurs because of the lack of attention to the customer's needs. Customer requirements and expectations must be recognized and addressed in a timely manner.

Customers are in an advantageous position, as they do not depend on one installation firm. If the project has been planned correctly from the beginning and suitable certified components have been specified, the professionalism of the ITS installer becomes a major factor in being selected.

Interpersonal Skills and Communication Requirements, continued

Each year a portion of an ITS contractor's base is lost due to:

- A move, discontinuation of business, or a merge with another company.
- Not staying with any vendor for an extended period of time for various reasons.
- Intentional abandonment by the ITS installation company.

Customers are not dependent on ITS installers; however, cabling installation companies are dependent on customers.

NOTE: Because of the technical language used in our industry, exercise care to use a level of communication the customer will understand.

Customer Perception

As the on-site representative of an employer, each employee carries certain responsibilities with respect to the relationship between the employer and the customer.

Either positive or negative, an impression is formed within the first 10 to 15 seconds of a first meeting. Therefore, it is in the employee's best interest to do everything possible to ensure a positive first impression.

Because of this, it is important to:

- Make a powerful and positive first impression.
- Maintain a professional image at all times.

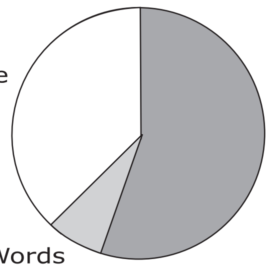
The way in which others perceive an employee can be broken down into three distinct areas:

- Body language
- Tone of voice
- Choice of words

Interpersonal Skills and Communication Requirements, continued

Figure 1.14 illustrates how communications perceptions are broken down in a face-to-face meeting with the customer. Body language makes the biggest impression, followed by the tone of voice and choice of words.

Figure 1.14
Communications perceptions



When talking with the customer on the telephone, the tone of voice and choice of words become much more critical. When communicating with the customer in writing, the only perception the customer obtains is through the choice of words and how those words are presented. Spelling, handwriting, and grammar become important in presenting a professional image.

It is important to understand the technical level of the person you are talking with, so that from a psychological point of view it is possible to create a positive relationship and not an adverse situation.

Feedback and Follow-Through

Feedback and follow-through are key to effective customer and coworker relationships. The customer must be kept informed. Any potential problems or concerns must be reported to the ITS installer's supervisor immediately.

This is especially true when it comes to project meetings. It is important to take time to prepare for the meeting, create and follow an organized agenda, and distribute copies of the presentation to all attendees.

When changes are made, record and acknowledge the changes with the customer and the ITS installer's organization. The ITS installer's follow-through is the bond that promotes trust, protects reputation, and helps to ensure that time and resource commitments are met.

Interpersonal Skills and Communication Requirements, continued

Professional Appearance

The ITS installer's appearance presents to the customer, coworkers, and supervisors an attitude about the quality of the work to be performed. Appearance must be appropriate for the task to be performed.

The ITS installer must recognize that appearance is a form of communication that can establish positive or negative expectations. Therefore, an organized, neat appearance, free from offensive or distracting items, is a benefit to ITS installers and the organization for which they work. Having and using appropriate safety equipment is part of that image.

NOTE: Refer to Section 2: Safety of this chapter for information on the available equipment and safety considerations.

References

BICSI. 2007. *OSP Design Reference Manual*. Tampa, FL: BICSI.

Telecommunications Industry Association, 2000. ANSI/TIA/EIA-568-B.3. *Optical Fiber Cabling Components Standard*. Arlington, VA: TIA.

