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Approved: April 12, 2001

TIA/EIA-568-B.1

# TIA/EIA STANDARD

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## Commercial Building Telecommunications Cabling Standard

### Part 1: General Requirements

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## TIA/EIA-568-B.1

(Revision of TIA/EIA-568-A)

MAY 2001

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TELECOMMUNICATIONS INDUSTRY ASSOCIATION



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(From Standards Proposal Nos.4425-B, 4425-B-1 and 4425-B-2, formulated under the cognizance of the TIA TR-42 Committee on User Premises Telecommunications Infrastructure.)

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## FOREWORD

(This foreword is not considered part of this Standard.)

### Approval of this Standard

This Standard was approved by TIA/EIA Subcommittee TR-42.1, TIA/EIA Engineering Committee TR-42, and the American National Standards Institute (ANSI).

ANSI/TIA/EIA reviews standards every 5 years. At that time, standards are reaffirmed, rescinded, or revised according to the submitted updates. Updates to be included in the next revision should be sent to the committee chair or to ANSI/TIA/EIA.

### Contributing organizations

More than 60 organizations within the telecommunications industry contributed their expertise to the development of this Standard (including manufacturers, consultants, end users, and other organizations).

Early in 1985, a large number of companies representing the telecommunications and computer industry expressed concern over the lack of a standard for building telecommunications cabling systems. The Computer Communications Industry Association (CCIA) asked the Electronic Industries Alliance (EIA) (formerly Association) to undertake the task of developing the required standard. EIA accepted the task and the project was assigned to Engineering Committee TR-42 (formerly TR-41.8). The TR-42 Committee contains the following subcommittees that are related to this activity.

- TR-42.1 - Subcommittee on Commercial Building Telecommunications Cabling
- TR-42.2 - Subcommittee on Residential Telecommunications Infrastructure
- TR-42.3 - Subcommittee on Commercial Building Telecommunications Pathways and Spaces
- TR-42.4 - Subcommittee on Outside Plant Telecommunications Infrastructure
- TR-42.5 - Subcommittee on Telecommunications Infrastructure Terms and Symbols
- TR-42.6 - Subcommittee on Telecommunications Infrastructure and Equipment Administration
- TR-42.7 - Subcommittee on Telecommunications Copper Cabling Systems
- TR-42.8 - Subcommittee on Telecommunications Optical Fiber Cabling Systems
- TR-42.9 - Subcommittee on Industrial Telecommunications Infrastructure

### Documents superseded

This Standard replaces ANSI/TIA/EIA-568-A dated October 6, 1995. Since the original publication of ANSI/EIA/TIA-568 in July of 1991, the office environment has undergone a period of rapid change marked by the growth of increasingly powerful personal computers, the access to more sophisticated applications and the need to interconnect different systems. These changes place increased demands on the transmission capacity of premises cabling. This trend has led to the development of twisted-pair cables, optical fiber cables, and corresponding compatible connecting hardware with enhanced transmission characteristics.

This Standard incorporates and refines the technical content of:

- TIA/EIA TSB67, *Transmission Performance Specifications for Field Testing of Unshielded Twisted-Pair Cabling Systems*
- TIA/EIA TSB72, *Centralized Optical Fiber Cabling*
- TIA/EIA TSB75, *Additional Horizontal Cabling Practices for Open Offices*
- TIA/EIA TSB95, *Additional Transmission Performance Guidelines for 4-Pair 100 W Category 5 Cabling*
- ANSI/TIA/EIA-568-A-1, *Propagation Delay and Delay Skew Specifications for 100 W 4-Pair Cable*
- ANSI/TIA/EIA-568-A-2, *Corrections and Additions to TIA/EIA-568-A*
- ANSI/TIA/EIA-568-A-3, *Addendum No. 3 to TIA/EIA-568-A*
- ANSI/TIA/EIA-568-A-4, *Production Modular Cord NEXT Loss Test Method and Requirements for Unshielded Twisted-Pair Cabling*
- ANSI/TIA/EIA-568-A-5, *Transmission Performance Specifications for 4-Pair 100 W Category 5e Cabling*
- TIA/EIA/IS-729, *Technical Specifications for 100 W Screened Twisted-Pair Cabling*

### **Significant technical changes from the previous edition**

- This foreword has been changed per the requirements of the TIA Style Manual.
- Reorganization of the ANSI/TIA/EIA-568-A standard to address cabling system requirements only and to have separate standards address component specifications.
- Incorporation of the above mentioned TSBs, Addenda, and Interim Standard.
- Definitions have been harmonized across all of TIA's telecommunications infrastructure standards.
- Performance specifications are provided for category 5e balanced 100-ohm cabling.
- Performance specifications are provided for 50/125  $\mu\text{m}$  optical fiber and cables.
- Small form factor optical fiber connector designs are allowed in addition to the 568SC.
- The term telecommunications closet has been replaced with telecommunications room.
- The permanent link has replaced the basic link as a test configuration.

### **Relationship to other TIA standards and documents**

This Standard is one of three technical standards that address commercial building cabling for telecommunications products and services. By referencing the two standards listed below, this Standard not only provides recommendations and specifications for the cabling system, but also its components. Each of the three standards may be reviewed and updated independently. The latest revision of each respective standard takes precedence over its previous edition.

- *Commercial Building Telecommunications Cabling Standard; Part 2: Balanced Twisted-Pair Cabling Components* (ANSI/TIA/EIA-568-B.2)
- *Optical Fiber Cabling Components Standard* (ANSI/TIA/EIA-568-B.3)

This Standard is one of a series of technical standards that address building cabling for telecommunications products and services. These series of standards include:

- *Commercial Building Standard for Telecommunications Pathways and Spaces* (ANSI/TIA/EIA-569-A)
- *Residential Telecommunications Cabling Standard* (ANSI/TIA/EIA-570-A)
- *Administration Standard for the Telecommunications Infrastructure of Commercial Buildings* (ANSI/TIA/EIA-606)
- *Commercial Building Grounding and Bonding Requirements for Telecommunications* (ANSI/TIA/EIA-607)
- *Customer-Owned Outside Plant Telecommunications Cabling Standard* (ANSI/TIA/EIA-758)

This Standard contains references to national and international standards. Where appropriate, international standards are used.

The following documents may be useful to the reader:

- *National Electrical Safety Code*<sup>®</sup> (NESC<sup>®</sup>)  
(IEEE C 2)
- *National Electrical Code*<sup>®</sup> (NEC<sup>®</sup>)  
(NFPA 70)

Useful supplements to this Standard are the Building Industry Consulting Service International (BICSI) *Telecommunications Distribution Methods Manual*, the *Customer-owned Outside Plant Design Manual*, and the *Telecommunications Cabling Installation Manual*. These manuals provide recommended practices and methods by which many of the requirements of this Standard may be implemented.

Other references are listed in annex F.

Annex A is normative and considered a mandatory part of this Standard. Annexes B through F are informative and not considered to be requirements of this Standard.

# 1 INTRODUCTION

## 1.1 Purpose

This Standard specifies a generic telecommunications cabling system for commercial buildings that will support a multi-product, multi-vendor environment. It also provides information that may be used for the design of telecommunications products for commercial enterprises.

The purpose of this Standard is to enable the planning and installation of a structured cabling system for commercial buildings. Installation of cabling systems during building construction or renovation is significantly less expensive and less disruptive than after the building is occupied.

This Standard establishes performance and technical criteria for various cabling system configurations for accessing and connecting their respective elements. In order to determine the requirements of a generic cabling system, performance requirements for various telecommunications services were considered.

The diversity of services currently available, coupled with the continual addition of new services, means that there may be cases where limitations to desired performance occur. When applying specific applications to these cabling systems, the user is cautioned to consult application standards, regulations, equipment vendors, and system and service suppliers for applicability, limitations, and ancillary requirements.

## 1.2 Specification of criteria

In accordance with EIA Engineering Publication, EP-7B, two categories of criteria are specified; mandatory and advisory. The mandatory requirements are designated by the word "shall"; advisory requirements are designated by the words "should", "may" or "desirable" which are used interchangeably in this Standard.

Mandatory criteria generally apply to protection, performance, administration and compatibility; they specify the absolute minimum acceptable requirements. Advisory or desirable criteria are presented when their attainment will enhance the general performance of the cabling system in all its contemplated applications.

A note in the text, table, or figure is used for emphasis or for offering informative suggestions.

## 1.3 Metric equivalents of US customary units

The majority of the metric dimensions in this Standard are soft conversions of US customary units; e.g., 100 millimeters is the soft conversion of 4 inches.

## 1.4 Life of this Standard

This Standard is a living document. The criteria contained in this Standard are subject to revisions and updating as warranted by advances in building construction techniques and telecommunications technology.

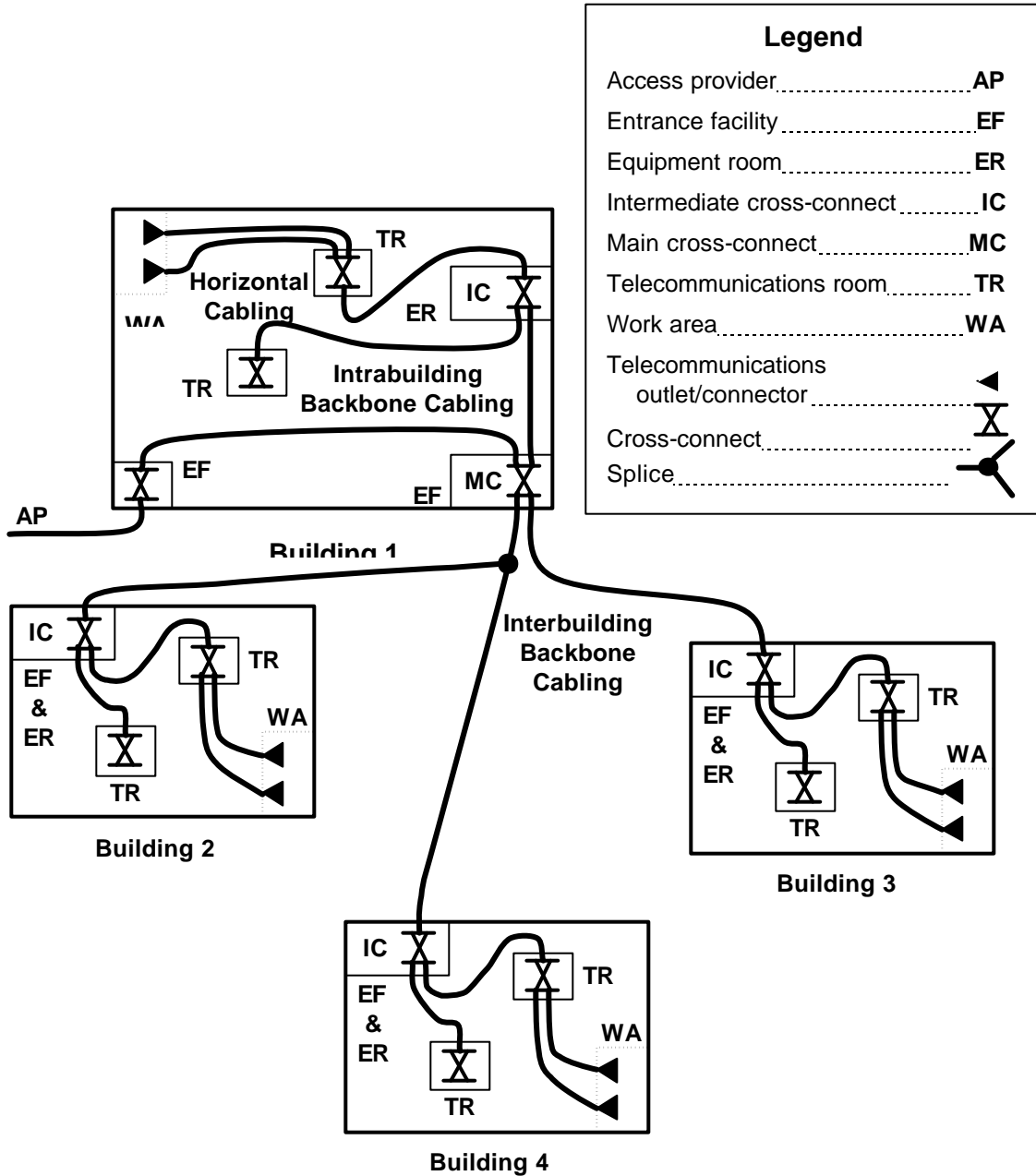
## **1.5 Telecommunications cabling system structure**

Figure 1-1 illustrates a representative model for the various functional elements that comprise a commercial building telecommunications cabling system. It depicts the relationship between the elements and how they are configured to create a total system.

The elements of the telecommunications cabling system structure are:

- a) Horizontal cabling (clause 4);
- b) Backbone cabling (clause 5);
- c) Work area (clause 6);
- d) Telecommunications rooms (clause 7);
- e) Equipment rooms (clause 8);
- f) Entrance facilities (clause 9); and,
- g) Administration.

NOTE – Basic administration information is covered in various locations throughout this Standard. Refer to ANSI/TIA/EIA-606 for more information regarding administration.



**NOTES**

1 – This figure is not meant to be an all-inclusive representation of the telecommunications cabling system and is provided only as a typical example.

2 – All cross-connects located in the telecommunications rooms (TRs) in this figure are horizontal cross-connects (HCs).

**Figure 1-1 Typical telecommunications cabling system**

## 2 SCOPE

This Standard specifies minimum requirements for telecommunications cabling within a commercial building and between buildings in a campus environment. It specifies cabling requirements, cabling distances, telecommunications outlet/connector configurations, and a recommended topology.

Building telecommunications cabling specified by this Standard is intended to support a wide range of different commercial building sites and applications (e.g., voice, data, text, video, and image). Typically, this range includes sites with a geographical extent from 3000 m (approximately 10 000 ft), up to 1 000 000 m<sup>2</sup> (approximately 10 000 000 ft<sup>2</sup>) of office space, and with a population of up to 50 000 individual users.

Telecommunications cabling systems specified by this Standard are intended to have a useful life in excess of ten years.

This Standard applies to the telecommunications cabling systems of buildings for commercial enterprises that are office oriented.

### 2.1 Normative references

The following standards contain provisions that, through reference in this text, constitute provisions of this Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision; parties to agreements based on this Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated. ANSI and TIA maintain registers of currently valid national standards published by them.

- a) ANSI/TIA/EIA-526-7, *Optical Power Loss Measurements of Installed Singlemode Fiber Cable Plant*
- b) ANSI/TIA/EIA-526-14-A, *Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant*
- c) ANSI/TIA/EIA-568-B.2, *Commercial Building Telecommunications Cabling Standard; Part 2: Balanced Twisted-Pair Cabling Components*
- d) ANSI/TIA/EIA-568-B.3, *Optical Fiber Cabling Components Standard*
- e) ANSI/TIA/EIA-569-A, *Commercial Building Standard for Telecommunications Pathways and Spaces*
- f) ANSI/TIA/EIA-570-A, *Residential Telecommunications Cabling Standard*
- g) ANSI/TIA/EIA-606, *Administration Standard for the Telecommunications Infrastructure of Commercial Buildings*
- h) ANSI/TIA/EIA-607, *Commercial Building Grounding/Bonding Requirements*
- i) ANSI/TIA/EIA-758, *Customer-Owned Outside Plant Telecommunications Cabling Standard*
- j) ASTM D 4566, *Standard Test Methods For Electrical Performance Properties Of Insulations And Jackets For Telecommunications Wire And Cable*
- k) IEC 60603-7, *Connectors for Frequencies below 3MHz for use with Printed Circuit Boards, Part 7: Detailed Specifications for Connectors, 8-way Including Fixed and Free Connectors with Common Mating Features*

NOTE - Although the title of IEC 60603-7 appears to limit the bandwidth of the 8-way modular connectors to 3MHz or less, these types of connectors may be qualified for use at higher frequencies when tested and proven to be compliant with the performance



requirements specified in ANSI/TIA/EIA-568-B.2.

### 3 DEFINITION OF TERMS, ACRONYMS AND ABBREVIATIONS, AND UNITS OF MEASURE

#### 3.1 General

This clause contains the definitions of terms, acronyms, and abbreviations that have special technical meaning or that are unique to the technical content of this Standard. Special definitions that are appropriate to individual technical clauses are also included.

#### 3.2 Definition of terms

The generic definitions in this clause have been formulated for use by the entire family of telecommunications infrastructure standards. Specific requirements are found in the normative clauses of this Standard. For the purposes of this Standard, the following definitions apply.

**access provider:** The operator of any facility that is used to convey telecommunications signals to and from a customer premises.

**adapter:** A device that enables any or all of the following:

- (1) different sizes or types of plugs to mate with one another or to fit into a telecommunications outlet,
- (2) the rearrangement of leads,
- (3) large cables with numerous wires to fan out into smaller groups of wires, and
- (4) interconnection between cables.

**adapter; optical fiber duplex:** A mechanical device designed to align and join two duplex optical fiber connectors (plugs) to form an optical duplex connection.

**administration:** The method for labeling, identification, documentation and usage needed to implement moves, additions and changes of the telecommunications infrastructure.

**attenuation:** The decrease in magnitude of transmission signal strength between points, expressed in dB as the ratio of output to input signal level.

**backbone:** A facility (e.g., pathway, cable or conductors) between telecommunications rooms, or floor distribution terminals, the entrance facilities, and the equipment rooms within or between buildings.

**backbone cable:** See **backbone**.

**bonding:** The permanent joining of metallic parts to form an electrically conductive path that will assure electrical continuity and the capacity to conduct safely any current likely to be imposed on it.

**bridged tap:** A connection that enables multiple appearances of the same cable pair at several distribution points.

**bundled cable:** An assembly of two or more cables continuously bound together to form a single unit.

**cable:** An assembly of one or more insulated conductors or optical fibers, within an enveloping sheath.

**cable run:** A length of installed media, which may include other components along its path.

**cable sheath:** A covering over the optical fiber or conductor assembly that may include one or more metallic members, strength members, or jackets.

**cabling:** A combination of all cables, jumpers, cords, and connecting hardware.

**campus:** The buildings and grounds having legal contiguous interconnection.

**centralized cabling:** A cabling configuration from the work area to a centralized cross-connect using pull through cables, an interconnect, or splice in the telecommunications room.

**channel:** The end-to-end transmission path between two points at which application-specific equipment is connected.

**commercial building:** A building or portion thereof that is intended for office use.

**connecting hardware:** A device providing mechanical cable terminations.

**connector, small form factor:** An optical fiber duplex connector with a size approximating that of an 8-position modular outlet/connector typically used for terminating 4-pair copper cable.

**consolidation point:** A location for interconnection between horizontal cables extending from building pathways and horizontal cables extending into furniture pathways.

**cord (telecommunications):** A cable using stranded conductors for flexibility, as in distribution cords or line cords.

**cross-connect:** A facility enabling the termination of cable elements and their interconnection or cross-connection.

**cross-connection:** A connection scheme between cabling runs, subsystems, and equipment using patch cords or jumpers that attach to connecting hardware on each end.

**customer premises:** Building(s), grounds and appurtenances (belongings) under the control of the customer.

**data:** Electronically encoded information.

**delay skew:** The difference in propagation delay between any two pairs within the same cable sheath.

**demarcation point:** A point where the operational control or ownership changes.

**drain wire:** A non-insulated conductor placed in electrical contact with a shield.

**electromagnetic interference:** Radiated or conducted electromagnetic energy that has an undesirable effect on electronic equipment or signal transmissions.

**end user:** The owner or user of the premises cabling system.

**entrance facility (telecommunications):** An entrance to a building for both public and private network service cables (including wireless) including the entrance point of the building and continuing to the entrance room or space.

**entrance point (telecommunications):** The point of emergence for telecommunications cabling through an exterior wall, a floor, or from a conduit.

**entrance room or space (telecommunications):** A space in which the joining of inter or intra building telecommunications backbone facilities takes place.

**equal level far-end crosstalk:** A measure of the unwanted signal coupling from a transmitter at the near-end into another pair measured at the far-end, and relative to the received signal level.

**equipment cable, cord:** A cable or cable assembly used to connect telecommunications equipment to horizontal or backbone cabling.

**equipment room (telecommunications):** An environmentally controlled centralized space for telecommunications equipment that usually houses a main or intermediate cross-connect.

**far-end crosstalk loss:** A measure of the unwanted signal coupling from a transmitter at the near end into another pair measured at the far end, and relative to the transmitted signal level.

**fiber optic:** See **optical fiber**.

**furniture cluster:** A contiguous group of work areas, typically including space divisions, work surfaces, storage, and seating.

**ground:** A conducting connection, whether intentional or accidental, between an electrical circuit (e.g., telecommunications) or equipment and the earth, or to some conducting body that serves in place of earth.

**high-order mode transient losses:** Losses in power caused by the attenuation in the cladding of multimode optical fiber.

**horizontal cabling:** (1) The cabling between and including the telecommunications outlet/connector and the horizontal cross-connect. (2) The cabling between and including the building automation system outlet or the first mechanical termination of the horizontal connection point and the horizontal cross-connect.

**horizontal cross-connect:** A cross-connect of horizontal cabling to other cabling, e.g., horizontal, backbone, and equipment.

**hybrid cable:** An assembly of two or more cables, of the same or different types or categories, covered by one overall sheath.

**hybrid optical fiber cable:** An optical fiber cable containing two or more fiber types (e.g., multimode and singlemode).

**infrastructure (telecommunications):** A collection of those telecommunications components, excluding equipment, that together provide the basic support for the distribution of all information within a building or campus.

**insertion loss:** The signal loss resulting from the insertion of a component, or link, or channel, between a transmitter and receiver (often referred to as attenuation).

**interconnection:** A connection scheme that employs connecting hardware for the direct connection of a cable to another cable without a patch cord or jumper.

**intermediate cross-connect:** A cross-connect between first level and second level backbone cabling.

**intra-building telecommunications backbone:** A pathway or cable facility for interconnecting telecommunications service entrance rooms, equipment rooms, or telecommunications rooms within a building.

**jumper:** An assembly of twisted-pairs without connectors, used to join telecommunications circuits/links at the cross-connect.

**keying:** The mechanical feature of a connector system that guarantees correct orientation of a connection, or prevents the connection to a jack, or to an optical fiber adapter of the same type intended for another purpose.

**link:** A transmission path between two points, not including terminal equipment, work area cables, and equipment cables.

**local exchange carrier:** The telecommunications company that provides public switched network access service.

**main cross-connect:** A cross-connect for first level backbone cables, entrance cables, and equipment cables.

**main terminal space:** The location of the cross-connect point of incoming cables from the telecommunications external network and the premises cable system.

**media (telecommunications):** Wire, cable, or conductors used for telecommunications.

**mode:** A path of light in an optical fiber.

**modular jack:** A female telecommunications connector that may be keyed or unkeyed and may have 6 or 8 contact positions, but not all the positions need be equipped with jack contacts.

**multimode optical fiber:** An optical fiber that carries many paths of light.

**multipair cable:** A cable having more than four pairs.

**multi-user telecommunications outlet assembly:** A grouping in one location of several telecommunications outlet/connectors.

**open office:** A floor space division provided by furniture, moveable partitions, or other means instead of by building walls.

**optical fiber:** Any filament made of dielectric materials that guides light.

**optical fiber cable:** An assembly consisting of one or more optical fibers.

**optical fiber duplex connection:** A mated assembly of two duplex connectors and a duplex adapter.

**outlet/connector (telecommunications):** A connecting device in the work area on which horizontal cable or outlet cable terminates.

**outside plant:** Telecommunications infrastructure designed for installation exterior to buildings.

**patch cord:** A length of cable with a plug on one or both ends.

**patch panel:** A connecting hardware system that facilitates cable termination and cabling administration using patch cords.

**pathway:** A facility for the placement of telecommunications cable.

**permanent link:** A test configuration for a link excluding test cords and patch cords.

**plenum:** A compartment or chamber to which one or more air ducts are connected and that forms part of the air distribution system.

**power sum equal level far-end crosstalk:** A computation of the unwanted signal coupling from multiple transmitters at the near-end into a pair measured at the far-end, and normalized to the received signal level.

**power sum near-end crosstalk loss:** A computation of the unwanted signal coupling from multiple transmitters at the near-end into a pair measured at the near-end.

**propagation delay:** The time required for a signal to travel from one end of the transmission path to the other end.

**rearrangement:** An action taken to replace, add, adapt or remove existing premises wiring system components.

**return loss:** A ratio expressed in dB of the power of the outgoing signal to the power of the reflected signal.

**room, telecommunications:** An enclosed space for housing telecommunications equipment, cable terminations, and cross-connect cabling, that is the recognized location of the horizontal cross-connect.

**screen:** An element of a cable formed by a shield.

**screened twisted-pair (ScTP):** A balanced cable with an overall screen.

**service entrance:** See **entrance facility (telecommunications)**.

**sheath:** See **cable sheath**.

**shield:** A metallic layer placed around a conductor or group of conductors.

**singlemode optical fiber:** An optical fiber that carries only one path of light.

**space (telecommunications):** An area used for housing the installation and termination of telecommunications equipment and cable, e.g., common equipment rooms, equipment rooms, common telecommunications rooms, telecommunications rooms, work areas, and maintenance holes/handholes.

**splice:** A joining of conductors in a splice closure, meant to be permanent.

**splice closure:** A device used to protect a splice.

**star topology:** A topology in which telecommunications cables are distributed from a central point.

**telecommunications:** Any transmission, emission, and reception of signs, signals, writings, images, and sounds, that is information of any nature by cable, radio, optical, or other electromagnetic systems.

**telecommunications entrance facility:** See **entrance facility (telecommunications)**.

**telecommunications entrance point:** See **entrance point (telecommunications)**.

**telecommunications entrance room or space:** See **entrance room or space (telecommunications)**.

**telecommunications equipment room:** See **equipment room (telecommunications)**.

**telecommunications infrastructure:** See **infrastructure (telecommunications)**.

**telecommunications outlet:** See **outlet/connector (telecommunications)**.

**telecommunications service entrance:** See **entrance facility (telecommunications)**.

**telecommunications space:** See **space (telecommunications)**.

**telecommunications room:** See **room, telecommunications**.

**terminal:** (1) a point at which information may enter or leave a communications network. (2) The input-output associated equipment. (3) A device by means of which wires may be connected to each other.

**termination position:** A discrete element of connecting hardware where telecommunications conductors are terminated.

**topology:** The physical or logical arrangement of a telecommunications system.

**transfer impedance:** A measure of shielding performance determined by the ratio of the voltage on the conductors enclosed by a shield to the surface currents on the outside of the shield.

**transition point:** A location in the horizontal cabling where flat undercarpet cable connects to round cable.

**wire:** An individually insulated solid or stranded metallic conductor.

**work area (work station):** A building space where the occupants interact with telecommunications terminal equipment.

**work area cable (cord):** A cable connecting the telecommunications outlet/connector to the terminal equipment.

### 3.3 Acronyms and abbreviations

ANSI	American National Standards Institute
AP	access provider
ASTM	American Society for Testing and Materials
ATM	asynchronous transfer mode
AWG	American Wire Gauge
BICSI	Building Industry Consulting Services International
CATV	community antenna television
CCIA	Computer Communications Industry Association
EF	entrance facility
EIA	Electronic Industries Alliance

ELFEXT	equal level far-end crosstalk
EMI	electromagnetic interference
EMS	energy management system
EP	entrance point
ER	equipment room
FCC	Federal Communications Commission
FDDI	fiber distributed data interface
FEXT	far-end crosstalk
FOCIS	Fiber Optic Connector Intermateability Standard
FTR	Federal Telecommunications Recommendation
HC	horizontal cross-connect
HVAC	heating, ventilation, and air conditioning
IC	intermediate cross-connect
IEC	International Electrotechnical Commission
IEEE	The Institute of Electrical and Electronics Engineers
IS	Interim Standard
ISDN	integrated services digital network
ISO	International Organization for Standardization
LAN	local area network
LED	light emitting diode
Mb/s	megabits per second
MC	main cross-connect
MUTOA	multi-user telecommunications outlet assembly
NCS	National Communications System
NEC®	National Electrical Code®
NEMA	National Electrical Manufacturers Association
NESC®	National Electrical Safety Code®
NEXT	near-end crosstalk
NFPA	National Fire Protection Association
NVP	nominal velocity of propagation
PSELFEXT	power sum equal level far-end crosstalk
PSFEXT	power sum far-end crosstalk
PSNEXT	power sum near-end crosstalk
ScTP	screened twisted-pair
STP	shielded twisted-pair
TR	telecommunications room
TGB	telecommunications grounding busbar
TIA	Telecommunications Industry Association
TSB	Telecommunications System Bulletin
UL	Underwriters Laboratories
US	United States
UTP	unshielded twisted-pair
WA	work area
X	cross-connect

### 3.4 Units of measure

°C	degrees Celsius
°F	degrees Fahrenheit
dB	decibel
ft	foot
GHz	gigahertz
in	inch
km	kilometer



lbf	pound force
m	meter
MHz	megahertz
mm	millimeter
N	newton
nm	nanometer
ns	nanosecond
V rms	volts root mean square
μm	micron or micrometer

## **4 HORIZONTAL CABLING**

### **4.1 General**

The horizontal cabling is the portion of the telecommunications cabling system that extends from the work area telecommunications outlet/connector to the horizontal cross-connect in the telecommunications room. The horizontal cabling includes horizontal cables, telecommunications outlet/connectors in the work area, mechanical terminations, and patch cords or jumpers located in the telecommunications room, and may include multi-user telecommunications outlet assemblies and consolidation points.

NOTE - The term "horizontal" is used since typically the cable in this part of the cabling system runs horizontally along the floor(s) or ceiling(s) of a building.

The following list of common services and systems should be considered when the horizontal cabling is designed. (The list is not intended to be complete.)

- a) Voice telecommunications service
- b) Premises switching equipment
- c) Data communications
- d) Local area networks (LAN)
- e) Video
- f) Other building signaling systems (building automation systems such as fire, security, HVAC, EMS, etc.)

In addition to satisfying today's telecommunications requirements, the horizontal cabling should be planned to reduce on-going maintenance and relocation. It should also accommodate future equipment and service changes. After construction of the building, the horizontal cabling is often much less accessible than the backbone cabling. The time, effort, and skills required for changes can be extremely high. In addition, access to the horizontal cabling frequently causes disruption to occupants and their work. These factors make the choice and layout of horizontal cable types very important to the design of the building cabling. Consideration should be given to accommodating a diversity of user applications in order to reduce or eliminate the probability of requiring changes to the horizontal cabling as user needs evolve.

The pathways and spaces shall be designed and installed to support horizontal cabling in accordance with the requirements of ANSI/TIA/EIA-569-A.

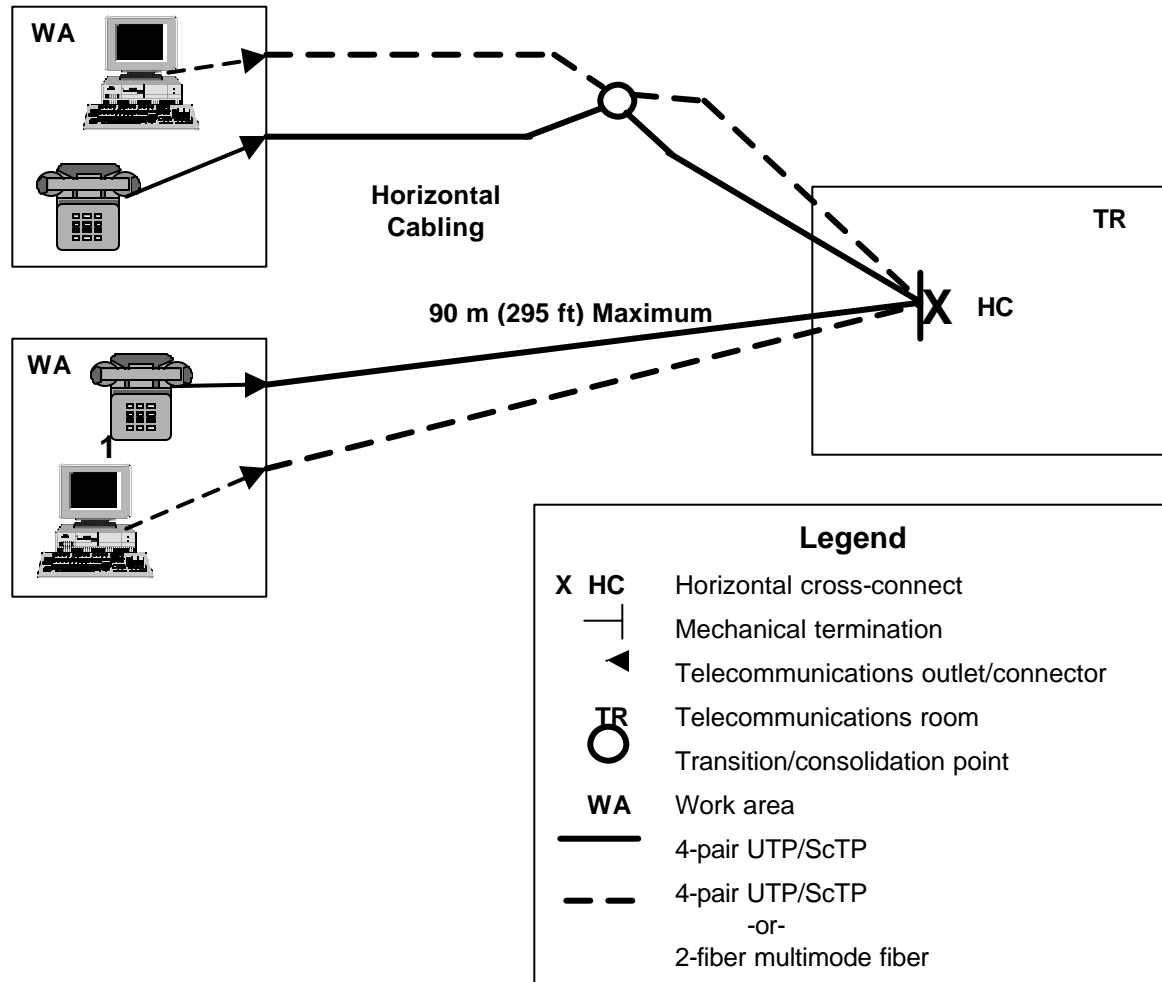
### **4.2 Topology**

The horizontal cabling shall be installed in a star topology as shown in figure 4-1. Each work area telecommunications outlet/connector shall be connected to a horizontal cross-connect in a telecommunications room via the horizontal cable. A telecommunications room should be located on the same floor as the work areas served.

Some networks or services require applications-specific electrical components (such as impedance matching devices). These application-specific electrical components shall not be installed as part of the horizontal cabling. When needed, such electrical components shall be placed external to the telecommunications outlet/connector. Keeping application-specific components external to the telecommunications outlet/connector will facilitate the use of the horizontal cabling for varying network and service requirements.

Horizontal cabling shall contain no more than one transition point or consolidation point between the horizontal cross-connect and telecommunications outlet.

Bridged taps and splices shall not be installed as part of the copper horizontal cabling. Splitters shall not be installed as part of the optical fiber horizontal cabling.



#### NOTES

1 – Cabling between telecommunications rooms for the purpose of creating "bus" and "ring" topologies is considered part of the backbone cabling. The direct connections between nearby telecommunications rooms are covered in subclause 5.2.3.

2 – Centralized optical fiber cabling is designed as an alternative to the optical cross-connection located in the telecommunications room when deploying recognized optical fiber cable in the horizontal in support of centralized electronics. Specifications concerning centralized cabling are found in annex A.

**Figure 4-1 Typical horizontal and work area cabling using a star topology**

### 4.3 Horizontal distances

The horizontal distance is the cable length from the mechanical termination of the media at the horizontal cross-connect in the telecommunications room to the telecommunications outlet/connector in

the work area. The maximum horizontal distance shall be 90 m (295 ft), independent of media type (see figure 4-1). If a multi-user telecommunications outlet assembly (MUTOA) is used, the maximum horizontal distances of copper media shall be reduced in accordance with subclause 6.4.1.4.

The length of the cross-connect jumpers and patch cords in the cross-connect facilities, including horizontal cross-connects, jumpers, and patch cords that connect horizontal cabling with equipment or backbone cabling, should not exceed 5 m (16 ft) in length. For each horizontal channel, the total length allowed for cords in the work area plus patch cords or jumpers plus equipment cables or cords in the telecommunications room shall not exceed 10 m (33 ft), unless a multi-user telecommunications assembly is used (see subclauses 6.4.1.4 and 6.4.1.5).

NOTE – In establishing the maximum distance for each horizontal channel, an allowance was made for 5m (16 ft) from the telecommunications outlet/connector to the work station.

#### **4.4 Recognized cables**

Two types of cables are recognized and recommended for use in the horizontal cabling system. These cables are:

- a) four-pair 100-ohm unshielded twisted-pair (UTP) or screened twisted-pair (ScTP) cables (ANSI/TIA/EIA-568-B.2)
- b) two or more optical fiber multimode cable, either 62.5/125  $\mu\text{m}$  or 50/125  $\mu\text{m}$  (ANSI/TIA/EIA-568-B.3)

At this time, 150-ohm shielded twisted-pair (STP-A) cable is a recognized media type (ANSI/TIA/EIA-568-B.2). It is not, however, recommended for new cabling installations and is expected to be removed from the next revision of this Standard.

Recognized cables, associated connecting hardware, jumpers, patch cords, equipment cords, and work area cords shall meet all applicable requirements specified in ANSI/TIA/EIA-568-B.2 and ANSI/TIA/EIA-568-B.3.

When bundled and hybrid cables are used for horizontal cabling, each cable type shall be recognized and meet the transmission and color-code specifications for that cable type given in ANSI/TIA/EIA-568-B.2 and ANSI/TIA/EIA-568-B.3. Additionally, bundled or hybrid copper cables shall meet the bundled or hybrid cable requirements in ANSI/TIA-568-B.2. These requirements apply to hybrid cables and bundled cables assembled prior to installation, sometimes referred to as loomed, speed-wrap, or whip cable constructions.

#### **NOTES**

1 – Annex C provides a brief description of a number of other horizontal cables that have been used in telecommunications. These cables, as well as others, may be effective for specific applications. Although these cables are not part of the requirements of this Standard, they may be used in addition to the minimum requirements of this Standard.

2 – Hybrid cables consisting of optical fiber and copper conductors are sometimes referred to as composite cables.

#### **4.5 Choosing types of cabling**

This Standard recognizes the importance of both voice and data telecommunications in a commercial building. A minimum of two telecommunications outlet/connectors shall be provided for each individual work area as shown in figure 4.1. One telecommunications outlet/connector may be associated with

voice and the other with data. Consideration should be given to installing additional outlets/connectors based on present and projected needs.

The two telecommunications outlet/connectors shall be configured as:

- a) One telecommunications outlet/connector shall be supported by a four-pair 100-ohm cable, category 3 or higher (category 5e recommended) as specified in ANSI/TIA/EIA-568-B.2.
- b) The other/second telecommunications outlet/connector(s) shall be supported by a minimum of one of the following horizontal media. This media choice should be based on present and projected needs.
  - 1) Four-pair 100-ohm category 5e cable as specified in ANSI/TIA/EIA-568-B.2.
  - 2) Two-fiber multimode optical fiber cable, either 62.5/125  $\mu\text{m}$  or 50/125  $\mu\text{m}$  as specified in ANSI/TIA/EIA-568-B.3

ANSI/TIA/EIA-568-B.2 and ANSI/TIA/EIA-568-B.3 requirements on compatible connectors shall be met. See subclause 6.2 for work area outlet/connector specifications.

#### **4.6 Grounding considerations**

Grounding systems are an integral part of the signal or telecommunications cabling system that they support. In addition to helping protect personnel and equipment from hazardous voltages, a proper grounding system may reduce electromagnetic interference (EMI) to and from the telecommunications cabling system. Improper grounding can produce induced voltages and those voltages can disrupt other telecommunications circuits.

Grounding and bonding shall meet the requirements and practices of applicable authorities or codes. In addition, telecommunications grounding/bonding shall conform to ANSI/TIA/EIA-607 requirements.

The shield of ScTP cables shall be bonded through a conducting path to the telecommunications grounding busbar (TGB) in the telecommunications room (see subclause 10.2.5). Grounding at the work area is usually accomplished through the equipment power connection. Shield connections at the work area are accomplished through an ScTP patch cord. At the work area end of the horizontal cabling, the voltage measured between the shield and the ground wire of the electrical outlet used to supply power to the work station shall not exceed 1.0 V rms. The cause of any higher voltage should be removed before using the cable.

## 5 BACKBONE CABLING

### 5.1 General

The function of the backbone cabling is to provide interconnections between telecommunications rooms, equipment rooms, main terminal space and entrance facilities in the telecommunications cabling system structure (see figure 1-1). Backbone cabling consists of the backbone cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for backbone-to-backbone cross-connection. Backbone cabling also includes cabling between buildings.

The backbone cabling is expected to serve the needs of building occupants for one or several planning periods, each period spanning three to ten years. During each planning period, the backbone cabling design should accommodate growth and changes in service requirements without the installation of additional cabling. The length of the planning period should be based upon the stability and growth of the end user organization.

In order to estimate the maximum amount of backbone cabling required, calculate the number of fibers or copper pairs that will be required in each backbone segment to support the maximum number of users and simultaneous applications projected for the planning period of the cabling system. Estimate the size of the cross-connect facilities to accommodate the cable and number of connections required.

### 5.2 Topology

#### 5.2.1 Star topology

The backbone cabling shall use the hierarchical star topology as illustrated by figure 5-1 wherein each horizontal cross-connect in a telecommunications room is cabled either directly to a main cross-connect or to an intermediate cross-connect, then to a main cross-connect. There shall be no more than two hierarchical levels of cross-connects in the backbone cabling. From the horizontal cross-connect, no more than one cross-connect shall be passed through to reach the main cross-connect. Therefore, connections between any two horizontal cross-connects shall pass through three or fewer cross-connect facilities (see figure 5-1).

Backbone cabling cross-connects may be located in telecommunications rooms, equipment rooms, or at entrance facilities. Bridged taps and splitters shall not be used as part of the backbone cabling.

#### NOTES

1 – The topology required by this Standard has been selected because of its acceptance and flexibility in meeting a variety of application requirements. The limitation to two levels of cross-connects is imposed to limit signal degradation for passive systems and to simplify moves, adds and changes. This limitation may not be suitable for facilities that have a large number of buildings or those that cover a large geographical area, such as universities, industrial parks and military bases. In these cases, it may be necessary to divide the entire facility into smaller areas within the scope of this Standard and then connect these areas together.

2 – The star topology is applicable to the individual units of the transmission medium, such as individual fibers or twisted-pairs. Depending on the physical characteristics of a site and the facility architecture, cable sub-units that are terminated at different locations may be part of the same cable over a portion of the distance or may use individual cables over the entire distance.

3 – Centralized optical fiber cabling is designed as an alternative to the optical cross-connection located in the telecommunications room when deploying recognized

optical fiber to the work area from a centralized cross-connect. Specifications concerning centralized cabling are found in annex A.

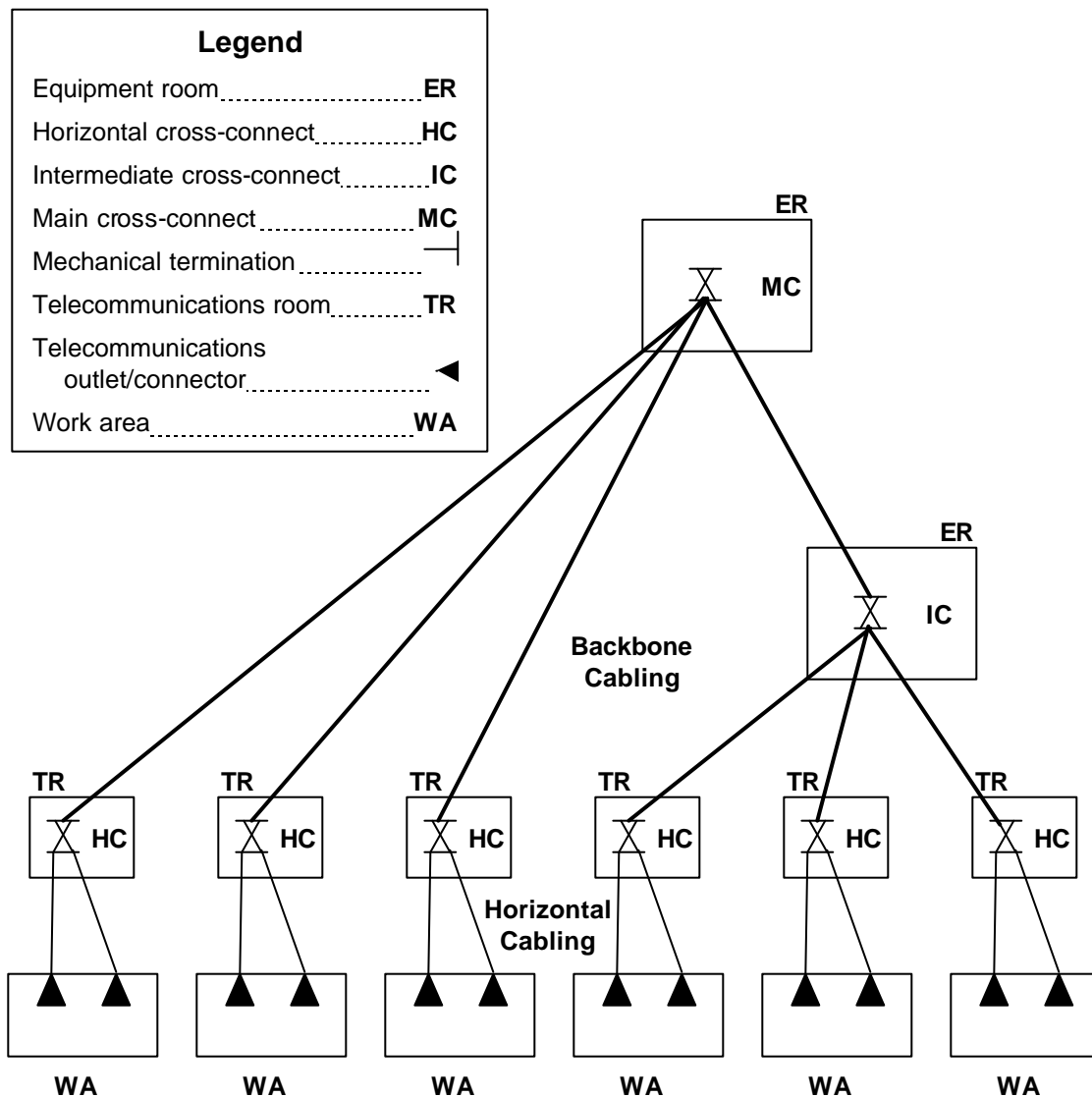


Figure 5-1 Backbone hierarchical star topology

### 5.2.2 Accommodation of non-star configurations

The topology in figure 5-1, through the use of appropriate interconnections, electronics, or adapters in the telecommunications rooms, can often accommodate systems that are designed for non-star configurations such as ring, bus, or tree.

### 5.2.3 Cabling directly between telecommunications rooms

If requirements for "bus" or "ring" configurations are anticipated, then cabling directly between telecommunications rooms is allowed. Such cabling is in addition to the connections for the star topology specified in subclause 5.2.1. See ANSI/EIA/TIA-569-A for pathway considerations.

### 5.3 Recognized cables

Due to the wide range of services and site sizes where backbone cabling will be used, more than one transmission medium is recognized. This Standard specifies transmission media, which shall be used individually or in combination in the backbone cabling. The recognized media are:

- a) 100-ohm twisted-pair cable (ANSI/TIA/EIA-568-B.2)
- b) multimode optical fiber cable, either 62.5/125  $\mu\text{m}$  or 50/125  $\mu\text{m}$  (ANSI/TIA/EIA-568-B.3)
- c) singlemode optical fiber cable (ANSI/TIA/EIA-568-B.3)

Recognized cables, associated connecting hardware, jumpers, patch cords, equipment cords, and work area cords shall meet all applicable requirements specified in ANSI/TIA/EIA-568-B.2 and ANSI/TIA/EIA-568-B.3.

#### NOTES

1 – Crosstalk between individual, unshielded twisted-pairs may affect the transmission performance of multipair copper cables. Annex B provides some shared sheath guidelines for multipair cables.

2 – Annex C provides a brief description of a number of other backbone cables that have been used in telecommunications. These cables, as well as others, may be effective for specific applications. Although these cables are not part of the requirements of this Standard, they may be used in addition to the minimum requirements of this Standard.

3 – See subclause 5.5 for backbone cabling distance limitations.

### 5.4 Choosing media

Backbone cabling specified by this Standard is applicable to a wide range of different user requirements. Depending upon the characteristics of the individual application, choices with respect to transmission media have to be made. In making this choice, factors to be considered include:

- a) flexibility with respect to supported services
- b) required useful life of backbone cabling
- c) site size and user population

Commercial building occupants' needs for telecommunications services vary over time and from occupant to occupant. Whenever possible, the different service requirements should first be determined. It is often convenient to group similar services together in a few groups such as voice, display terminal, local area networks (LAN), and other connections. Within each group, individual service types should be identified and required cabling usage projected.

When future service requirements are not well defined, use "worst case" scenarios when evaluating different backbone cabling alternatives. The higher the uncertainty, the more flexible the backbone cabling system needs to be.

Each recognized cable has individual characteristics that make it useful in a variety of situations. A single cable type may not satisfy all end user requirements. It is then necessary to use more than one medium in the backbone cabling. In those instances, the different media shall use the same facility architecture with the same location for cross-connects, mechanical terminations, interbuilding entrance facilities, etc.



## 5.5 Backbone cabling distances

### 5.5.1 Intra and interbuilding distances

The maximum supportable distances are application and media dependent. The maximum backbone distances specified in figure 5-2 are guidelines based on voice transmission for balanced twisted-pair cabling (maximum 800 m [2624 ft]) and the applications listed in annex E for optical fiber cabling. The distances given are for the total backbone channel length, including backbone cable, patch cords or jumpers, and equipment cable.

To minimize cabling distances, it is often advantageous to locate the main cross-connect near the center of a site. Cabling installations that exceed these distance limits may be divided into areas, each of which can be supported by backbone cabling within the scope of this Standard. Interconnections between the individual areas, which are outside the scope of this Standard, may be accomplished by employing equipment and technologies normally used for wide area applications.

The length of category 3 multipair balanced 100-ohm backbone cabling, that supports applications up to 16 MHz, should be limited to a total of 90 m (295 ft).

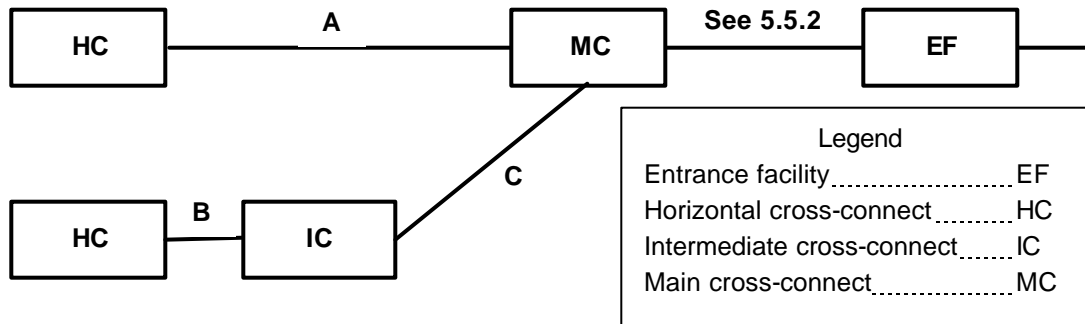
The length of category 5e multipair balanced 100-ohm backbone cabling, that supports data applications up to 100 MHz, should be limited to a total distance of 90 m (295 ft).

The 90 m (295 ft) distance allows for an additional 5 m (16 ft) at each end for equipment cables (cords) connecting to the backbone.

#### NOTES

1 – The 90 m (295 ft) distance limitation assumes uninterrupted cabling runs between cross-connects that serve equipment (i.e., no intermediate cross-connect).

2 – Users of this document are advised to consult the specific standards associated with the planned service, or equipment manufacturers and systems integrators to determine the suitability of the cabling described herein for specific applications.



Media Type	A	B	C
100-ohm twisted-pair	800 m (2624 ft) maximum see 5.5.1	300 m (984 ft) maximum see 5.5.1	500 m (1640 ft) see 5.5.1
62.5/125 $\mu$ m optical fiber	2000 m (6560 ft) maximum	300 m (984 ft) maximum	1700 m (5575 ft)
50/125 $\mu$ m optical fiber	2000 m (6560 ft) maximum	300 m (984 ft) maximum	1700 m (5575 ft)
Singlemode optical fiber	3000 m (9840 ft) maximum	300 m (984 ft) maximum	2700 m (8855 ft)

**NOTES:**

1 – While it is recognized that the capabilities of singlemode fiber may allow for backbone link distances of up to 60 km (37 miles), this distance is generally considered to extend outside the scope of this Standard.

2 – Specific applications may exist, or become available in the future, that do not operate over the maximum distances specified. For example, to support access providers, it may be necessary to insert repeaters or regenerators (outside the scope of this Standard) along the backbone cabling.

3 – It is recommended that users selecting multimode fiber use either 62.5/125  $\mu$ m or 50/125  $\mu$ m fiber cable for new installation and additions. The user should consider both multimode and singlemode fiber cable to support backbone cabling systems.

**Figure 5-2 Backbone distances**

When the horizontal cross-connect (HC) to intermediate cross-connect (IC) distance is less than maximum, the intermediate cross-connect (IC) to main cross-connect (MC) distance can be increased accordingly. However, the total distance from the horizontal cross-connect (HC) to the main cross-connect (MC) shall not exceed the maximum specified in figure 5-2, column A.

**5.5.2 Main cross-connect to entrance facility**

The distance between the entrance facility and the main cross-connect shall be included in the total distance calculations when regulatory policies within the jurisdiction, which relate to the location of the demarcation point, deem it appropriate. The length and type of media (including gauge size for copper) shall be recorded and should be made available to the access provider upon request.

### **5.5.3 Cross-connections**

In the main cross-connect, jumper and patch cord lengths should not exceed 20 m (66 ft). In the intermediate cross-connect, jumper and patch cord lengths should not exceed 20 m (66 ft).

### **5.5.4 Cabling to telecommunications equipment**

The length of the cable used to connect telecommunications equipment directly to the main or intermediate cross-connect should not exceed 30 m (98 ft).

## **5.6 Grounding and bonding considerations**

Grounding systems are an integral part of the telecommunications cabling system that they support. In addition to helping protect personnel and equipment from hazardous voltages, a proper grounding system may reduce electromagnetic interference (EMI) to and from the telecommunications cabling system. Improper grounding can produce induced voltages and those voltages can disrupt other telecommunications circuits.

Grounding and bonding shall meet the appropriate requirements and practices of applicable authorities or codes. Additionally, grounding and bonding shall conform to ANSI/TIA/EIA-607.

## 6 WORK AREA

### 6.1 General

The work area components extend from the telecommunications outlet/connector end of the horizontal cabling system to the work station equipment. The work station equipment can be any of a number of devices including but not limited to telephones, data terminals and computers. Work area cabling is critical to a well-managed distribution system; however, it is generally non-permanent and easy to change.

### 6.2 Telecommunications outlet/connector

#### 6.2.1 100-Ohm balanced twisted-pair telecommunications outlet/connector

Each 4-pair cable shall be terminated in an eight-position modular jack at the work area. The 100-ohm UTP and ScTP telecommunications outlet/connector shall meet the modular interface requirements specified in IEC 60603-7. In addition, the telecommunications outlet/connector for 100-ohm UTP and ScTP cable shall meet the requirements of ANSI/TIA/EIA-568-B.2 and the terminal marking and mounting requirements specified in ANSI/TIA/EIA-570-A.

Pin/pair assignments shall be as shown in figure 61 or, optionally, per figure 62 if necessary to accommodate certain 8pin cabling systems. The colors shown are associated with the horizontal distribution cable. These illustrations depict the front view of the telecommunications outlet/connector.

NOTE - US Federal Government publication NCS, FTR 1090-1997 recognizes designation T568A only.

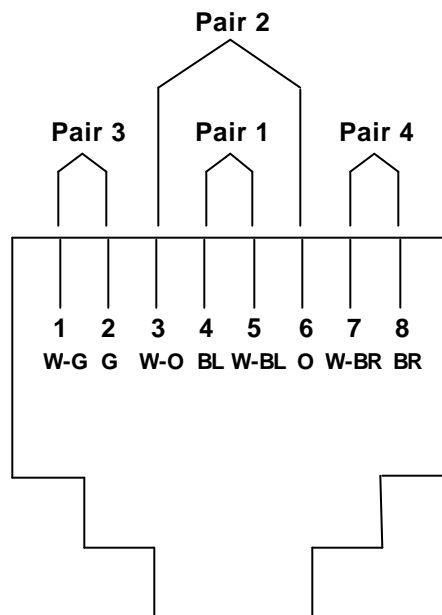
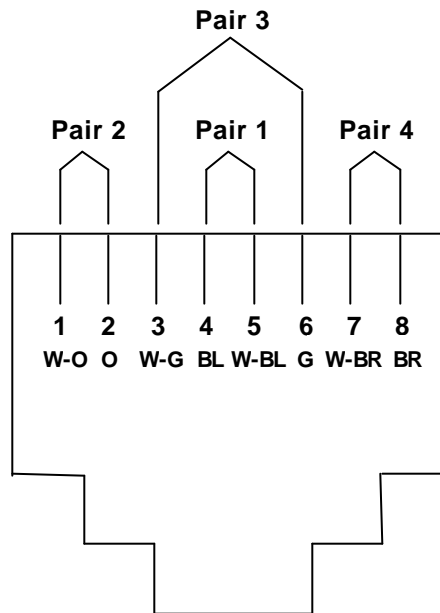


Figure 6-1 Eight-position jack pin/pair assignments (T568A)



**Figure 6-2 Optional eight-position jack pin/pair assignment (T568B)**

### 6.2.2 Optical fiber telecommunications outlet connector

Horizontal optical fibers at the work area outlet shall be terminated to a duplex optical fiber outlet/connector meeting the requirements of ANSI/TIA/EIA-568-B.3. To facilitate inter-office moves, consider the use of one style of duplex connector for the work area outlet. The 568SC connector was previously specified by ANSI/TIA/EIA-568-A and should continue to be considered for the work area outlet. Other connector styles, including those of a small form factor, may also be considered.

### 6.3 Work area cords

The maximum horizontal cable length is specified in subclause 4.3 and is based on a maximum length of 5 m (16 ft) of work area cord. Patch cords used in the work area shall meet or exceed the performance requirements in ANSI/TIA/EIA-568-B.2 and ANSI/TIA/EIA-568-B.3.

Work area cabling may vary in form depending on the application. A cord with identical connectors on both ends is commonly used. When application specific adaptations are needed at the work area, they shall be external to the telecommunications outlet/connector (see subclause 4.2). Some of the most commonly encountered adaptations at the work area are:

- a) a special cable or adapter is required when the equipment connector is different from the telecommunications outlet/connector.
- b) a "Y" adapter is required when two services run on a single cable.
- c) passive adapters that may be needed when the cable type in the horizontal cabling is different from the cable type required by the equipment.
- d) active adapters that may be needed when connecting devices that use different signaling schemes.
- e) pair transposition adapters that may be necessary for compatibility.
- f) termination resistors required for ISDN terminals.

NOTE – When used, cabling adapters in the work area may have detrimental effects on the transmission performance of the telecommunications cabling system. Therefore, it is important that their compatibility with premises cabling, equipment and applications be considered before they are connected to the telecommunications network

## 6.4 Open office cabling

Recent office design practices have introduced flexible layouts designed to support collaborative work by small teams. Such spaces are frequently rearranged to meet changing requirements of concentrated individual work and collaborative group work. Many other open office work situations also require frequent reconfiguration. An interconnection in the horizontal cabling allows open office spaces to be reconfigured frequently without disturbing horizontal cable runs.

### 6.4.1 Multi-user telecommunications outlet assembly

Multi-user telecommunications outlet assemblies (MUTOAs) may be advantageous in open office spaces that are moved or reconfigured frequently. A multi-user telecommunications outlet assembly facilitates the termination of single or multiple horizontal cables in a common location within a furniture cluster or similar open area. The use of multi-user telecommunications outlet assemblies allows horizontal cabling to remain intact when the open office plan is changed. Work area cables originating from the multi-user telecommunications outlet assembly should be routed through work area pathways (e.g., furniture pathways). The work area cables shall be connected directly to work station equipment without the use of any additional intermediate connections (see figure 6-3).

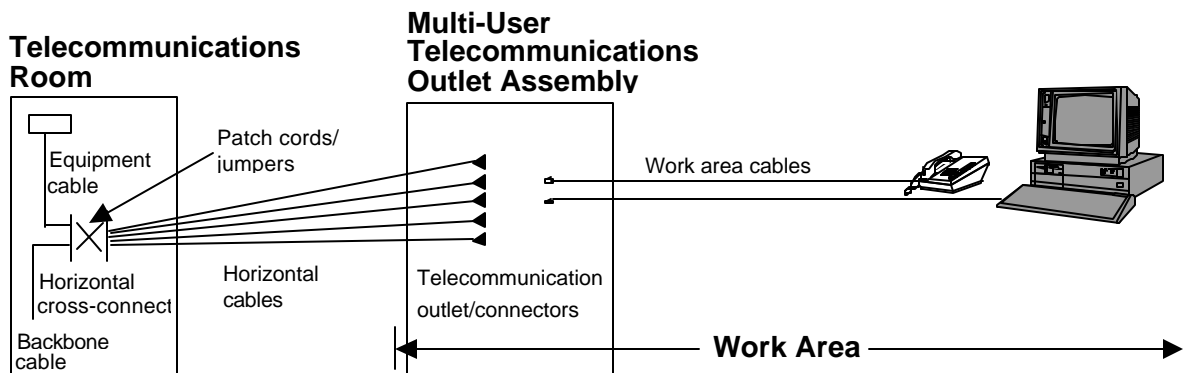


Figure 6-3 Application of multi-user telecommunications outlet assembly

#### 6.4.1.1 Application planning

Multi-user telecommunications outlet assemblies should be located in an open work area so that each furniture cluster is served by at least one multi-user telecommunications outlet assembly. The multi-user telecommunications outlet assembly should be limited to serving a maximum of twelve work areas. Maximum work area cable length requirements (see subclause 6.4.1.4) shall also be taken into account. Spare capacity should also be considered when sizing the multi-user telecommunications outlet assembly.

#### 6.4.1.2 Installation practices

Multi-user telecommunications outlet assemblies shall be located in fully accessible, permanent locations such as building columns, and permanent walls. Multi-user telecommunications outlet assemblies shall not be located in ceiling spaces, or any obstructed area. Multi-user telecommunications outlet assemblies shall not be installed in furniture unless that unit of furniture is permanently secured to the building structure.

### 6.4.1.3 Administration

Multi-user telecommunications outlet assemblies shall be administered in the same manner as outlets described in ANSI/TIA/EIA-606.

The work area cables connecting the multi-user telecommunications outlet assembly to the work areas shall be labeled on both ends with a unique cable identifier. The end of the work area cables at the multi-user telecommunications outlet assembly shall be labeled with the work area it serves, and the end at the work area shall be labeled with the multi-user telecommunications outlet assembly identifier and a port identifier.

### 6.4.1.4 Maximum lengths for copper cabling

Copper work area cables used in the context of multi-user telecommunications outlet assemblies and open office furniture, shall meet the requirements of ANSI/TIA/EIA-568-B.2. Based upon insertion loss considerations, the maximum length shall be determined according to:

$$C = (102 - H)/(1+D) \quad (1)$$

$$W = C - T \quad \begin{matrix} \text{£ 22 m (72 ft) for 24 AWG UTP/ScTP or} \\ \text{£ 17 m (56 ft) for 26 AWG ScTP} \end{matrix} \quad (2)$$

Where:

*C* is the maximum combined length (m) of the work area cable, equipment cable, and patch cord.

*H* is the length (m) of the horizontal cable ( $H + C \leq 100$  m).

*D* is a de-rating factor for the patch cord type (0.2 for 24 AWG UTP/24 AWG ScTP and 0.5 for 26 AWG ScTP).

*W* is the maximum length (m) of the work area cable

*T* is the total length of patch and equipment cords in the telecommunications room.

Table 6-1 applies the above formulae assuming that there is a total of 5 m (16 ft) of 24 AWG UTP/24 AWG ScTP or 4 m (13 ft) of 26 AWG ScTP patch cords and equipment cables in the telecommunications room. The multi-user telecommunications outlet assembly shall be marked with the maximum allowable work area cable length. One method to accomplish this is to evaluate cable length markings.

**Table 6-1 Maximum length of horizontal and work area cables**

Length of horizontal cable  <b>H</b> m (ft)	24 AWG UTP/24 AWG ScTP patch cords		26 AWG ScTP patch cords	
	Maximum length of work area cable  <b>W</b> m (ft)	Maximum combined length of work area cables, patch cords, and equipment cable  <b>C</b> m (ft)	Maximum length of work area cable  <b>W</b> m (ft)	Maximum combined length of work area cables, patch cords, and equipment cable  <b>C</b> m (ft)
90 (295)	5 (16)	10 (33)	4 (13)	8 (26)
85 (279)	9 (30)	14 (46)	7 (23)	11 (35)
80 (262)	13 (44)	18 (59)	11 (35)	15 (49)
75 (246)	17 (57)	22 (72)	14 (46)	18 (59)
70 (230)	22 (72)	27 (89)	17 (56)	21 (70)

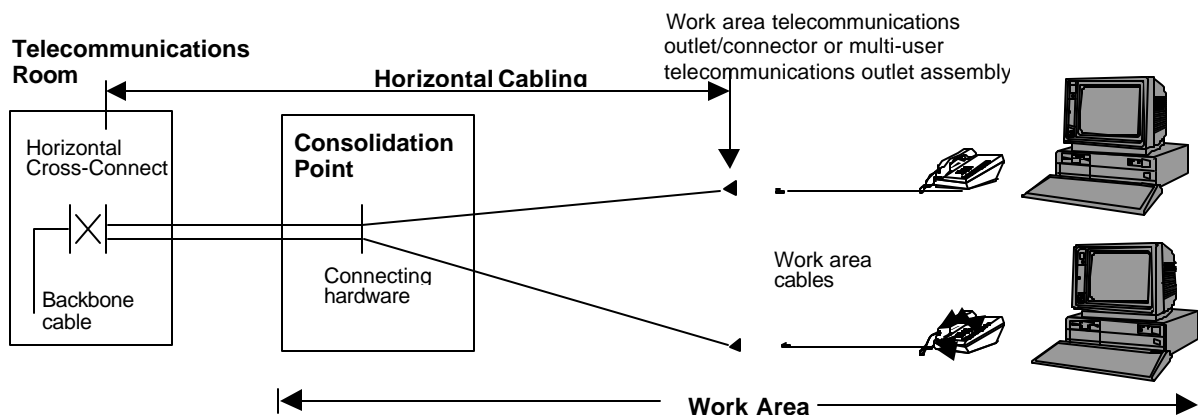
### 6.4.1.5 Horizontal distances of optical fiber links (long work area cables)

For optical fiber cables, extending the lengths of work area cables to reach a multi-user telecommunications outlet assembly does not require reduction of the total channel length allowance of 100 m (328 ft). When deploying a centralized fiber cabling network, the guidelines of annex A shall be followed.

### 6.4.2 Consolidation point

The consolidation point is an interconnection point within the horizontal cabling using ANSI/TIA/EIA-568-B.2 or ANSI/TIA/EIA-568-B.3 compliant connecting hardware installed in accordance with the requirements of clause 10 and rated for at least 200 cycles of reconnection. It differs from the multi-user telecommunications outlet assembly in that it requires an additional connection for each horizontal cable run. Cross-connections shall not be used at a consolidation point. No more than one consolidation point shall be used within the same horizontal cable run. A transition point and consolidation point shall not be used in the same horizontal-cabling link. Each horizontal cable extending to the work area outlet from the consolidation point shall be terminated to a telecommunications outlet/connector or multi-user telecommunications outlet assembly, provided the requirements of subclause 6.4.1.4 and the transmission performance of clause 11 are met. The cables and connections used at a consolidation point shall meet the requirements of ANSI/TIA/EIA-568-B.2 or ANSI/TIA/EIA-568-B.3 and be installed in accordance with the requirements of clause 10 (see figure 6-4).

For copper cabling, in order to reduce the effect of multiple connections in close proximity on NEXT loss and return loss, the consolidation point should be located at least 15 m (49 ft) from the telecommunications room.



**Figure 6-4 Application of consolidation point**

A consolidation point may be useful when reconfiguration is frequent, but not so frequent as to require the flexibility of the multi-user telecommunications outlet assembly.

#### 6.4.2.1 Application planning

Consolidation points should be located in an open work area so that each furniture cluster is served by at least one consolidation point. The consolidation point should be limited to serving a maximum of twelve work areas. Spare capacity should also be considered when sizing the consolidation point.



**6.4.2.2 Installation practices**

Consolidation points shall be located in fully accessible, permanent locations such as building columns, and permanent walls. Consolidation points shall not be located in any obstructed area. Consolidation points shall not be installed in furniture unless that unit of furniture is secured to the building structure. Consolidation points shall not be used for direct connection to active equipment.

**6.4.2.3 Administration**

Consolidation points shall be administered in the same manner as connecting hardware described in ANSI/TIA/EIA-606. Moves, adds, and changes of service not associated with open office rearrangements should be implemented at the horizontal cross-connect in the telecommunications room.

## **7 TELECOMMUNICATIONS ROOMS**

### **7.1 General**

Telecommunications rooms (TRs) provide many different functions for the cabling system and are often treated as a distinct sub-system within the hierarchical cabling system described in clauses 4 and 5.

### **7.2 Design**

Telecommunications rooms shall be designed and provisioned according to the requirements in ANSI/EIA/TIA-569-A.

### **7.3 Functions**

The primary function of a telecommunications room is the termination of horizontal and backbone cables to compatible connecting hardware. The cross-connection of horizontal and backbone cable terminations using jumpers or patch cords allows flexible connectivity when extending various services to telecommunications outlet/connectors. Connecting hardware, jumpers, and patch cords used for this purpose are collectively referred to as “horizontal cross-connections”.

A telecommunications room may also contain the intermediate cross-connect or the main cross-connect for different portions of the backbone cabling system. Sometimes backbone-to-backbone cross-connections in the telecommunications room are used to tie different telecommunications rooms together in a ring, bus, or tree configuration as described in subclause 5.2.2.

A telecommunications room also provides a controlled environment to house telecommunications equipment, connecting hardware, and splice closures serving a portion of the building. The telecommunications room provides for the administration and routing of the equipment cables/cords from the horizontal cross-connect to the telecommunications equipment. In some cases, the demarcation point and associated protection apparatus may be located in the telecommunications room.

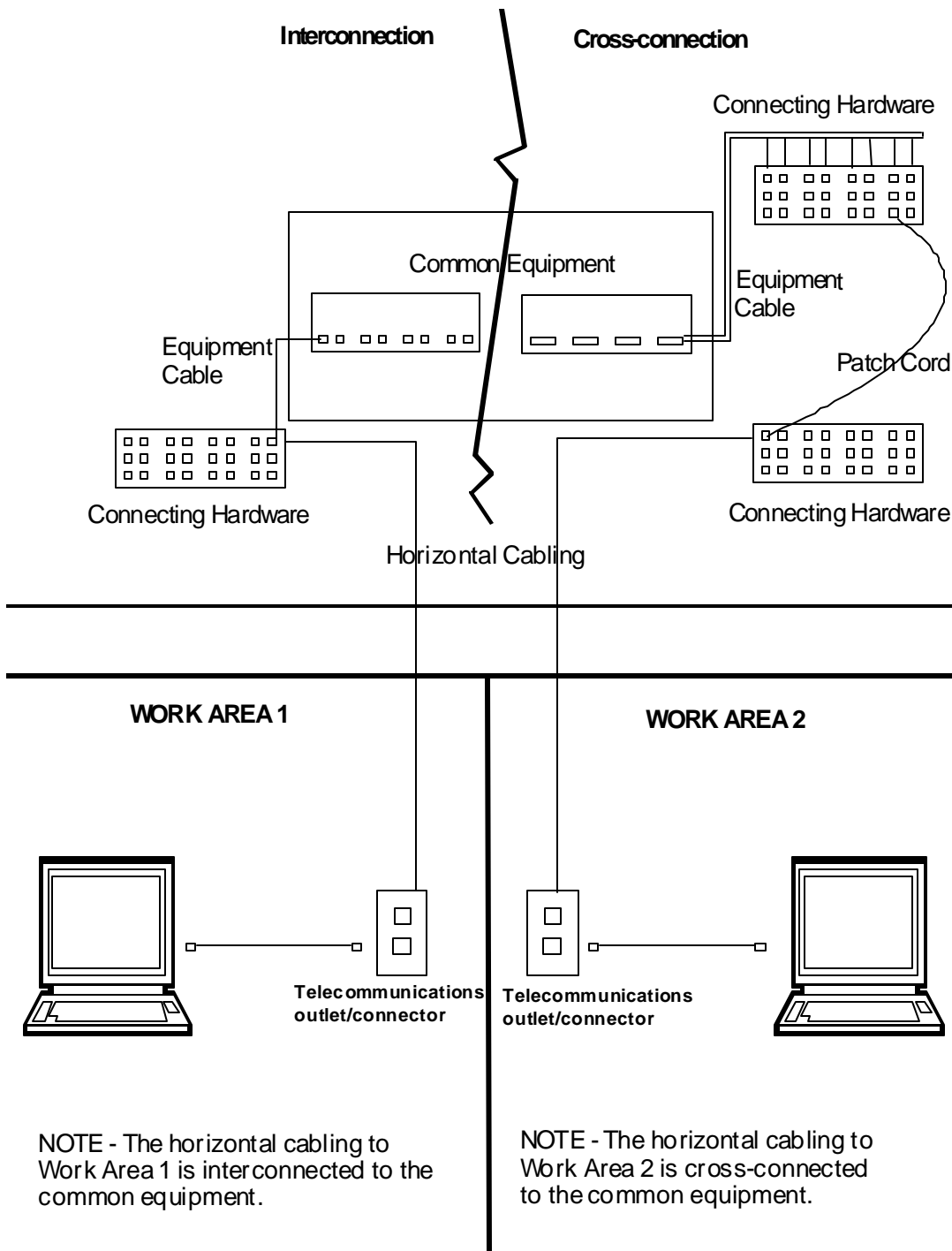
### **7.4 Cross-connections and interconnections**

Horizontal and backbone building cables shall be terminated on connecting hardware that meets the requirements of ANSI/TIA/EIA-568-B.2 and ANSI/TIA/EIA-B.3. These cable terminations shall not be relocated to implement cabling system moves, adds, and changes. All connections between horizontal and backbone cables shall be cross-connections.

NOTE – Centralized optical fiber cabling is designed as an alternative to the optical cross-connect located in the telecommunications room, when deploying recognized optical fiber cable in the horizontal in support of centralized electronics. Specifications concerning centralized cabling are found in annex A.

Equipment cables/cords that consolidate several ports on a single connector shall be terminated on dedicated connecting hardware. Equipment cables/cords that extend a single port appearance may either be permanently terminated or interconnected directly to horizontal or backbone terminations. Direct interconnections reduce the number of connections in a link, but may reduce flexibility (see figure 7-1).

## TELECOMMUNICATIONS ROOM



**Figure 7-1 Illustration of interconnection and cross-connection schemes**

## **8 EQUIPMENT ROOMS**

### **8.1 General**

Equipment rooms (ERs) are considered to be distinct from telecommunications rooms because of the nature or complexity of the equipment they contain. An equipment room may alternately provide any or all of the functions of a telecommunications room.

### **8.2 Design**

Equipment rooms shall be designed and provisioned according to the requirements in ANSI/TIA/EIA-569-A.

### **8.3 Functions**

An equipment room provides a controlled environment to house telecommunications equipment, connecting hardware, splice closures, grounding and bonding facilities, and protection apparatus where applicable.

From a cabling perspective, an equipment room may contain either the main cross-connect or the intermediate cross-connect used in the backbone cabling hierarchy. Alternatively, the main cross-connect may be located in the main terminal space. The equipment room provides for the administration and routing of the equipment cables/cords from the main or intermediate cross-connect to the telecommunications equipment. See ANSI/TIA/EIA-569-A for additional information.

An equipment room may also house equipment terminations (and may contain horizontal terminations for a portion of the building). In many cases, the equipment room contains access provider (e.g., local telephone company) trunk terminations, premises network terminations, and auxiliary terminations that are under the control of the premises cabling administrator.

### **8.4 Cabling practices**

Cabling cross-connections and interconnections described in subclause 7.4 for telecommunications rooms are also applicable to equipment rooms.

## **9 ENTRANCE FACILITIES**

### **9.1 General**

The entrance facility (EF) consists of the cables, connecting hardware, protection devices, and other equipment needed to connect the outside plant facilities to the premises cabling. These components may be used for regulated access providers (e.g., local telephone companies), private network customer premises services, or both. The demarcation point between the regulated access providers and the customer premises cabling may be part of the entrance facility.

### **9.2 Design**

The entrance facility pathway(s) and space(s) shall be designed and installed in accordance with the requirements of ANSI/TIA/EIA-569-A.

### **9.3 Functions**

#### **9.3.1 Network demarcation point**

The demarcation point between access providers and the customer premises cabling may be part of the entrance facilities. The location of this point for regulated access providers is determined by federal/state regulations. The access provider should be contacted to determine the location policies in effect for the area.

#### **9.3.2 Electrical protection**

Electrical protection is governed by the applicable electrical codes. Interbuilding backbone cables and antennas may require protection devices. Access providers should be contacted to determine the needs and policies.

#### **9.3.3 Bonding and grounding**

The bonding and grounding requirements of ANSI/TIA/EIA-607 shall be followed.

#### **9.3.4 Entrance facility connections**

The entrance facilities include connections between cabling used in the outside environment and cabling authorized for in-building distribution. This connection may be accomplished via a splice or other means. Campus backbone cabling shall comply with ANSI/TIA/EIA-758.

## **10 CABLING INSTALLATION REQUIREMENTS**

### **10.1 General**

The following installation requirements, in addition to the other clauses of this Standard, shall be followed. Cabling shall comply with applicable codes and regulations.

#### **10.1.1 Placement of horizontal and backbone cables**

Cable and components shall be visually inspected for proper installation. Cable stress, such as that caused by tension in suspended cable runs and tightly cinched bundles, should be minimized. Cable ties used to bundle cables should be applied loosely to allow the cable tie to slide around the cable bundle. The cable ties should not be cinched so tightly as to deform the cable sheath. Cable placement should not deform the cable sheath.

Applicable codes and regulations shall be determined prior to beginning work.

### **10.2 Balanced 100-ohm twisted-pair cabling (UTP and ScTP)**

#### **10.2.1 Minimum bend radius**

The minimum bend radius for cable will vary depending on the condition of the cable during installation (tensile load) and after installation when the cable is at rest (no-load).

##### **10.2.1.1 Minimum horizontal cable bend radius**

The minimum bend radius, under no-load conditions, for 4-pair unshielded twisted-pair (UTP) cable shall be four times the cable diameter and the minimum bend radius of 4-pair screened twisted-pair (ScTP) cable, under no-load conditions, shall be eight times the cable diameter.

##### **10.2.1.2 Minimum backbone cable bend radius**

The minimum bend radius, under no-load conditions, for multipair backbone cable shall be ten times the cable diameter.

##### **10.2.1.3 Minimum patch cable bend radius**

The minimum bend radius, under no load conditions, for 4-pair UTP patch cable is under further study.

#### **10.2.2 Maximum pulling tension**

The maximum pulling tension of 4-pair 24 AWG UTP cable shall be 110 N (25 lbf). For multipair backbone cable, manufacturer's pulling tension guidelines shall be followed.

#### **10.2.3 Connecting hardware termination**

Cables should be terminated with connecting hardware of the same category or higher. The transmission characteristics of the cable and connector categories have been specified such that the impact of connectors, patch cords, and cross-connect jumpers on link performance are minimized.

Connector and cable components that meet these requirements are not sufficient in themselves to ensure adequate installed cabling system performance. As with all cabling media, additional considerations that may degrade transmission performance of installed cabling systems include cabling practices that relate to connector terminations, cable management, the use of cross-connect jumpers or patch cords, and the effects of multiple connections in close proximity.

Installed transmission performance of components that meet requirements of different performance categories (i.e., cables, connectors, and patch cords that are not rated for the same transmission capability) shall be classified by the least performing component in the link.

To maintain the cable geometry, remove the cable sheath only as much as necessary to terminate the cable pairs on the connecting hardware. The connecting hardware manufacturer's instructions for cable sheath strip-back shall be followed.

When terminating category 5e and higher cables, the cable pair twists shall be maintained to within 13 mm (0.5 in) from the point of termination. When terminating category 3 cables, the cable pair twists shall be maintained to within 75 mm (3 in) from the point of termination. For best performance when terminating cable on connecting hardware, the cable pair twists should be maintained as close as possible to the point of termination.

#### **10.2.4 Patch cords, equipment cords, work area cords, and jumpers**

Cross-connect jumpers and cables used for patch cords should be of the same performance category or higher as the horizontal cables to which they connect. Patch cords are also used for equipment cords and work area cords. Patch cords should not be field terminated. To minimize return loss degradation, unjacketed jumper wire shall not be made in the field by removing the jacket in large part or its entirety from a previously jacketed cable.

#### **10.2.5 100-Ohm ScTP grounding requirements**

When terminating ScTP cable, the drain wire shall be bonded to the connecting hardware in accordance with the manufacturer's instructions. The connecting hardware at the cross-connect shall be bonded to an ANSI/TIA/EIA-607 grounding and bonding system.

### **10.3 Optical fiber cabling**

#### **10.3.1 Minimum bend radius and maximum pulling tension**

The bend radius for intrabuilding 2 and 4-fiber horizontal optical fiber cable shall not be less than 25 mm (1 in) under no-load conditions. When under a maximum tensile load of 222 N (50 lbf), the bend radius shall not be less than 50 mm (2 in).

The bend radius for intrabuilding optical fiber backbone cable shall not be less than that recommended by the manufacturer. If no recommendation is known, then the applied bend radius shall not be less than 10 times the cable outside diameter under no-load conditions and not less than 15 times the cable outside diameter when the cable is under tensile load.

The bend radius for interbuilding optical fiber backbone cable shall not be less than that recommended by the manufacturer. If no recommendation is provided or known, then the bend radius shall not be less than 10 times the cable outside diameter under no-load conditions and not less than 20 times the cable outside diameter when the cable is under a tensile load up to the rating of the cable, usually 2670 N (600 lbf).

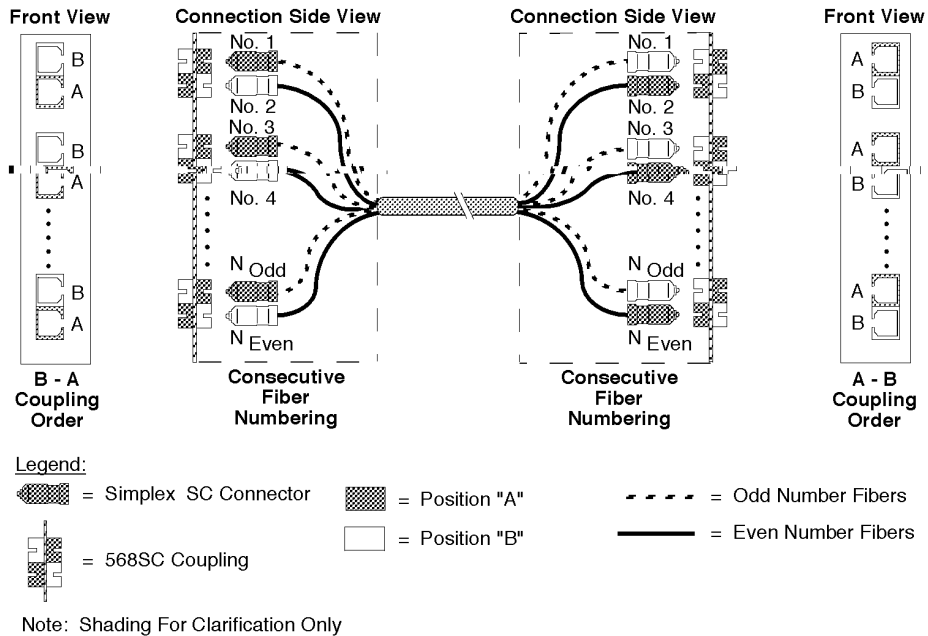
#### **10.3.2 Connecting hardware termination and polarity**

Each cabling segment shall be installed such that odd numbered fibers are Position A at one end and Position B at the other end while the even numbered fibers are Position B at one end and Position A at the other end. This approach is illustrated in figure 10-1.

The 568SC implementation shall be achieved by using consecutive fiber numbering (i.e., 1,2,3,4...) on both ends of an optical fiber link, but the 568SC adapters shall be installed in opposite manners on each end (i.e., A-B, A-B... on one end and B-A, B-A... on the other). This approach is illustrated in figure 10-1.

For other duplex connector styles, polarity may be achieved either by using the above method for the 568SC or by using reverse-pair positioning. Reverse-pair positioning is achieved by installing fibers in consecutive fiber numbering (i.e., 1,2,3,4....) on one end of an optical fiber link and reverse-pair numbering (i.e., 2,1,4,3....) on the other end of the optical fiber link.

Figure 10-2 illustrates the proper orientation of the 568SC adapter at the MC, IC, HC and telecommunications outlet/connector to ensure proper polarity of an optical fiber system from the main cross-connect to the telecommunications outlet/connector. Optical fiber links not shown in figure 10-2 shall be installed to ensure that on one end, the 568SC adapter is installed in the A-B orientation and, on the other end, installed in the B-A orientation.



**Figure 10-1 Specified optical fiber cabling for proper polarity (wall-mount hardware shown)**



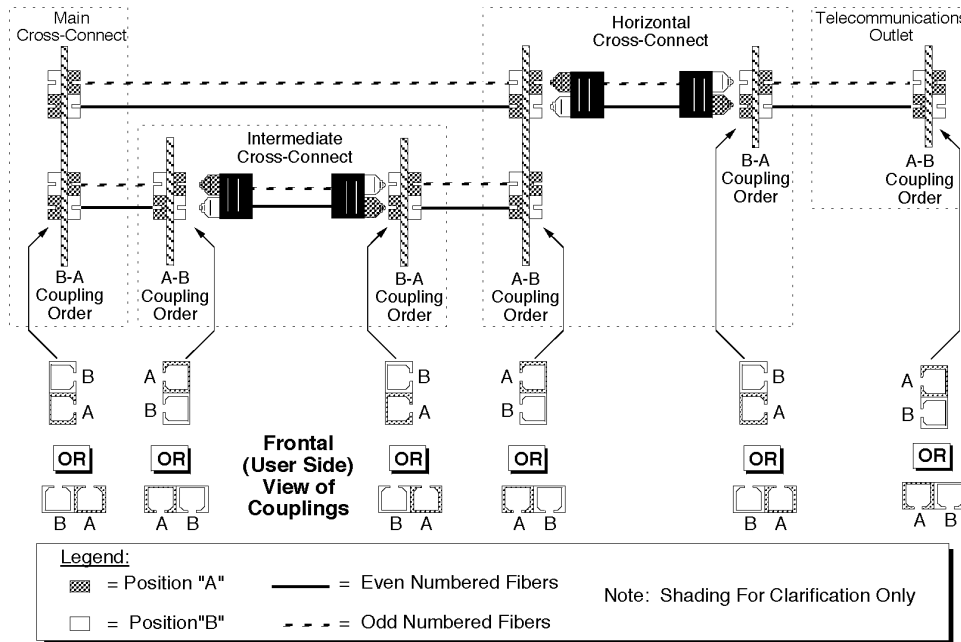


Figure 10-2 Optical fiber cabling plan for premises cabling

### 10.3.3 Patch cords, equipment cords and work area cords

The optical fiber patch cords shall consist of 2-fiber cables, of the same fiber type as the optical fiber channel, terminated with connectors at both ends. Patch cords are also used for equipment cords and work area cords. Optical fiber patch cords shall be configured so that A connects to B and B connects to A (see figure 10-3).

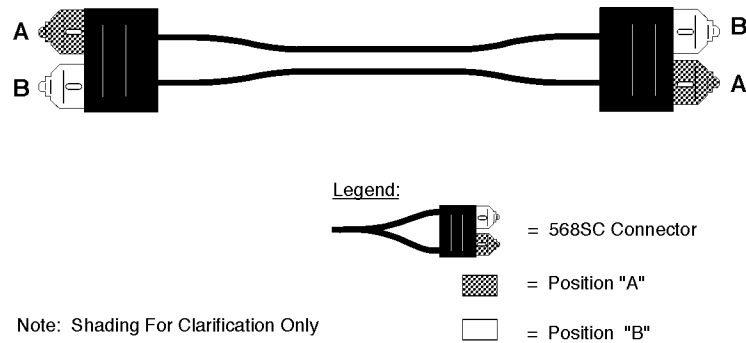


Figure 10-3 568SC optical fiber patch cord

## **10.4 150-Ohm shielded twisted-pair cabling**

### **10.4.1 Minimum bend radius**

The minimum bend radius for 150-ohm STP-A, under no-load conditions, shall be 75 mm (3 in) for non-plenum cable, and 150 mm (6 in) for plenum cable.

### **10.4.2 Maximum pulling tension**

The maximum pulling tension of 150-ohm STP-A cable shall be 244 N (55 lbf).

### **10.4.3 Connecting hardware termination**

When terminating STP-A cable, the shield shall be bonded to the connector in accordance with the manufacturer's instructions. The connecting hardware at the cross-connect shall be bonded to an ANSI/TIA/EIA-607 grounding and bonding system.

## **11 CABLING TRANSMISSION PERFORMANCE AND TEST REQUIREMENTS**

### **11.1 General**

Transmission performance depends on cable characteristics, connecting hardware, patch cords and cross-connect wiring, the total number of connections, and the care with which they are installed and maintained. This clause addresses field test specifications for post-installation performance measurements of cabling designed in accordance with this Standard.

The information contained in this Standard is related to the channel and to the permanent link test configurations as specified in the following subclauses. This clause provides additional information, including specifications for field test instruments, test methods and interpretations of test results, leading to a practical solution to the issues related to field-testing.

### **11.2 100-Ohm twisted-pair transmission performance and field test requirements**

#### **11.2.1 Purpose and scope**

This subclause specifies the electrical characteristics of field test instruments, test methods, and minimum transmission requirements for 100-ohm twisted-pair cabling. The purpose of this subclause is to specify transmission performance requirements for 100-ohm twisted-pair cabling links that are consistent with the two categories of 100-ohm twisted-pair cable and connecting hardware specified herein. The requirements are targeted towards field-testing of installed 100-ohm twisted-pair cabling links using field test instruments. Field test instrument characteristics needed for swept/stepped frequency measurements up to 100 MHz are described to ensure consistent and reasonably accurate measurements. Other methods using frequency domain or time domain measurement techniques that demonstrate equivalency are acceptable.

NOTE – Category 5 cabling transmission performance and test recommendations previously found in TIA/EIA TSB67 are in annex D.

Field test methods and interpretation of test data leading to Pass/Fail criteria are described to verify the installed cabling. Users of this subclause are advised to consult applications standards, equipment manufacturers and system integrators to determine the suitability of these requirements for specific networking applications.

This subclause contains additional specifications for verification of installed cabling and is not intended to replace or supersede the basic requirements of this Standard.

#### **11.2.2 Applicability**

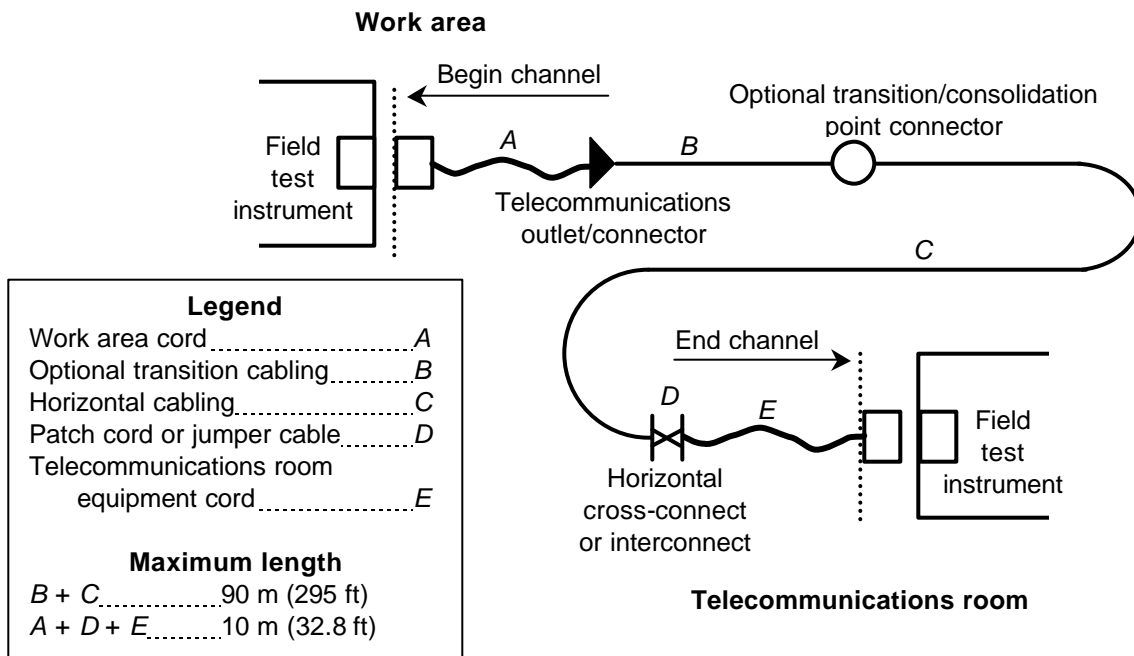
The transmission requirements specified herein are applicable to unshielded twisted-pair (UTP) and screened twisted-pair (ScTP) cabling links consisting of cables and connecting hardware specified in this Standard. This subclause relates to performance with respect to 100-ohm 4-pair UTP and ScTP cabling only. Compliance with this specification does not imply compatibility with cables having nominal impedance values other than 100-ohm.

#### **11.2.3 Test configurations**

This subclause is intended to specify requirements for field test instruments and procedures for field measurement practices that will yield repeatable measurements of installed 100-ohm twisted-pair cabling links.

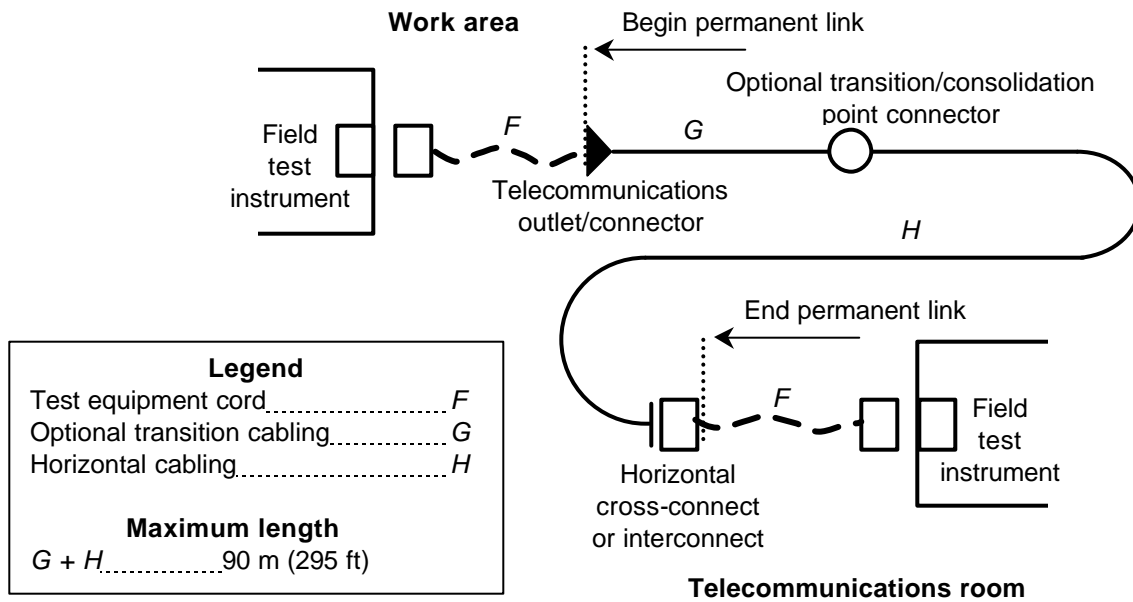
Channel and permanent link test configurations are defined in the following paragraphs. Other compliant test configurations shall be tested using limits computed according to subclause 11.2.4.

The channel test configuration is to be used by system designers and users of data communications systems to verify the performance of the overall channel. The channel includes up to 90 m (295 ft) of horizontal cable, a work area equipment cord, a telecommunications outlet/connector, an optional transition/consolidation connector, and two connections in the telecommunications room. The total length of equipment cords, patch cords or jumpers and work area cords shall not exceed 10 m (33 ft). The connections to the equipment at each end of the channel are not included in the channel definition. The channel definition does not apply to those cases where the horizontal cabling is cross-connected to the backbone cabling. See figure 11-1 for a schematic representation of a channel.



**Figure 11-1 Schematic representation of a channel test configuration**

The permanent link test configuration is to be used by installers and users of data telecommunications systems to verify the performance of permanently installed cabling. A schematic representation of the permanent link is illustrated in figure 11-2. The permanent link consists of up to 90 m (295 ft) of horizontal cabling and one connection at each end and may also include an optional transition/consolidation point connection. The permanent link excludes both the cable portion of the field test instrument cord and the connection to the field test instrument.



**Figure 11-2 Schematic representation of a permanent link test configuration**

NOTE – If cross-connections are used, then channel testing is recommended.

## 11.2.4 Test parameters

### 11.2.4.1 General

The primary field test parameters are:

- Wire map
- Length
- Insertion loss
- Near-end crosstalk (NEXT) loss
- Power sum near-end crosstalk (PSNEXT) loss
- Equal-level far-end crosstalk (ELFEXT)
- Power sum equal-level far-end crosstalk (PSELFEXT)
- Return loss
- Propagation delay
- Delay skew

NOTE – Other parameters such as longitudinal balance and longitudinal impedance, which may be of importance to specific networking applications, are under study.

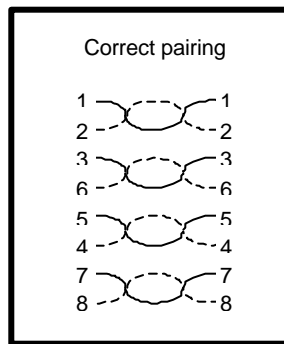
Insertion loss, near-end crosstalk loss, equal level far-end crosstalk, and return loss are derived from swept/stepped frequency measurements or equivalent measurement methods.

### 11.2.4.2 Wire map

The wire map test is intended to verify pin-to-pin termination at each end and check for installation connectivity errors. For each of the 8 conductors in the cable, the wire map indicates:

- a) continuity to the remote end
- b) shorts between any two or more conductors
- c) reversed pairs
- d) split pairs
- e) transposed pairs
- f) any other miswiring

Correct connectivity of telecommunications outlets/connectors is defined in ANSI/TIA/EIA-568-B.2 and is illustrated in figure 11-3.



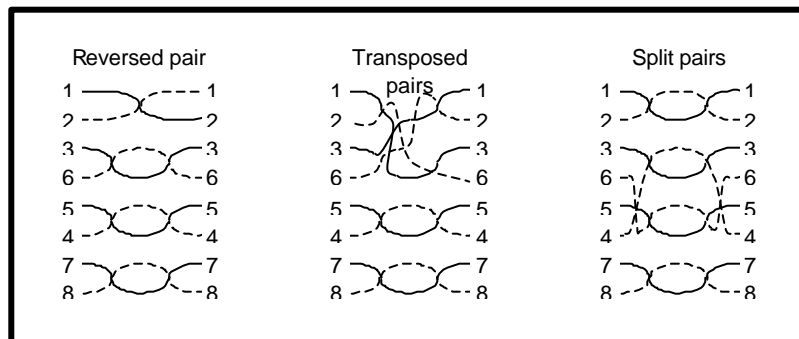
**Figure 11-3 Correct pairing**

A reversed pair occurs when the polarity of one wire pair is reversed at one end of the link (also called a Tip/Ring reversal). Refer to figure 11-4 for an illustration of a reversed pair.

A transposed pair occurs when the two conductors in a wire pair are connected to the position for a different pair at the remote connection. Refer to figure 11-4 for an illustration of transposed pairs.

NOTE – Pair transpositions are sometimes referred to as crossed pairs.

Split pairs occur when pin-to-pin continuity is maintained, but physical pairs are separated. Refer to figure 11-4 for an illustration of split pairs.



**Figure 11-4 Incorrect pairing**

### 11.2.4.3 Length

#### 11.2.4.3.1 Physical length vs. electrical length

The physical length of the permanent link/channel is the sum of the physical lengths of the cables between the two end points. Physical length of the permanent link/channel may be determined by physically measuring the length(s) of the cable(s), determined from the length markings on the cable(s), when present, or estimated from the electrical length measurement. The electrical length is derived from the propagation delay of signals and depends on the construction and material properties of the cable (see ANSI/TIA/EIA-568-B.2).

When physical length is determined from electrical length, the physical length of the link calculated using the pair with the shortest electrical delay shall be reported and used for making the Pass or Fail decision. The Pass or Fail criteria is based on the maximum length allowed for the channel or permanent link given in figures 11-1 and 11-2 plus the nominal velocity of propagation (NVP) uncertainty of 10 percent.

NOTE – Calibration of NVP is critical to the accuracy of length measurements (see ANSI/TIA/EIA-568-B.2).

#### 11.2.4.3.2 Length requirements

The maximum physical length of the permanent link shall be 90 m (295 ft) (test equipment cords are excluded from the permanent link model). The maximum physical length of the channel shall be 100 m (328 ft) (including equipment cords and patch cords).

#### 11.2.4.4 Insertion loss

Insertion loss is a measure of signal loss in the permanent link or channel. Worst case insertion loss relative to the maximum insertion loss allowed shall be reported.

The channel insertion loss is derived as the sum of:

- a) insertion loss of four connectors,
- b) insertion loss of 10 m (33 ft) of 24 AWG UTP/24 AWG ScTP patch, work area, and equipment cords or 8 m (26 ft) of 26 AWG ScTP patch, work area, and equipment cords at 20° C, and;
- c) insertion loss of 90 m (295 ft) cable segment at 20° C.

The permanent link insertion loss is derived as the sum of:

- a) insertion loss of three connectors,
- b) insertion loss of 90 m (295 ft) cable segment at 20° C.

Insertion loss requirements are derived from the following equations:

$$\textit{insertion loss}_{channel} = \textit{insertion loss}_{4connections} + \textit{insertion loss}_{cable,90m} + \textit{insertion loss}_{cords,10m} \quad (3)$$

$$\textit{insertion loss}_{permanentlink} = \textit{insertion loss}_{3connections} + \textit{insertion loss}_{cable,90m} \quad (4)$$

The maximum insertion loss contribution allowed for equipment cords and patch cords is 20 percent higher than for the horizontal cabling as specified in ANSI/TIA/EIA-568-B.2. The maximum insertion loss contribution allowed for ScTP equipment cords and patch cords is 50 percent higher than for the horizontal cabling as specified in ANSI/TIA/EIA-568-B.2. If 50 percent de-rating is used, the maximum

total length of patch cables, equipment cords, and work area cords shall be 8 m (26 ft), so that the overall insertion loss limits for the channel are not exceeded.

Examples of the worst case insertion loss at selected frequencies for the channel and permanent link are shown in tables 11-1 and 11-2 respectively.

**Table 11-1 Insertion loss @ 20 °C for channel test configuration**

Length of horizontal cabling: 90 m (295 ft)

Length of equipment cords, patch cords and jumpers: 10 m (33 ft)

Frequency (MHz)	Category 3 (dB)	Category 5e (dB)
1.0	4.2	2.2
4.0	7.3	4.5
8.0	10.2	6.3
10.0	11.5	7.1
16.0	14.9	9.1
20.0	--	10.2
25.0	--	11.4
31.25	--	12.9
62.5	--	18.6
100.0	--	24.0

NOTE – Category 3 channel insertion loss requirements are derived using a connecting hardware contribution of 0.4 dB per connection point over the frequency range of 1–16 MHz. The category 3 connecting hardware requirements of ANSI/TIA/EIA-568-B.2 provide additional margin to the channel requirements.

**Table 11-2 Insertion loss @ 20 °C for permanent link test configuration**

Length of horizontal cable: 90 m (295 ft)

Frequency (MHz)	Category 3 (dB)	Category 5e (dB)
1.0	3.5	2.1
4.0	6.2	3.9
8.0	8.9	5.5
10.0	9.9	6.2
16.0	13.0	7.9
20.0	--	8.9
25.0	--	10.0
31.25	--	11.2
62.5	--	16.2
100.0	--	21.0

NOTE – Category 3 permanent link insertion loss requirements are derived using a connecting hardware contribution of 0.4 dB per connection point over the frequency range of 1 – 16 MHz. The category 3 connecting hardware requirements of ANSI/TIA/EIA-568-B.2 provide additional margin to the permanent link requirements.



Insertion loss increases with temperature. The user can estimate the insertion loss of cable segments at temperatures other than 20 °C using a 1.5% degree Celsius factor for category 3 cable and a 0.4% per degree Celsius factor for category 5e cable. The temperature coefficient and the maximum temperatures are specified in ANSI/TIA/EIA-568-B.2.

#### NOTES

1 – When using percent variations in quantities normally expressed in dB, this subclause uses percent variations in the dB values.

2 – Although the terms attenuation and insertion loss are often used interchangeably, attenuation implies that the terminating impedance at the device under test is the same as the characteristic impedance of the cable.

#### 11.2.4.5 Pair-to-pair NEXT loss

Pair-to-pair NEXT loss is a measure of signal coupling from one pair to another within a 100-ohm twisted-pair cabling link and is derived from swept/stepped frequency or equivalent voltage measurements. Pair-to-pair NEXT loss shall be measured in accordance with ASTM D 4566 and annex D of ANSI/TIA/EIA-568-B.2

For all frequencies from 1 MHz to the highest test frequency, all pair combinations shall meet the pair-to-pair NEXT values determined using equations (5) and (6) for the channel and permanent link, respectively. NEXT loss values greater than 60 dB shall revert to a requirement of 60 dB. The values in tables 11-3 and 11-4 are provided for information only.

NOTE –  $NEXT_{cable}$  and  $NEXT_{connector}$  are the cable and connecting hardware NEXT loss respectively, as defined in ANSI/TIA/EIA-568-B.2.

$$NEXT_{channel} = -20 \log \left( 10^{\frac{NEXT_{cable}}{20}} + 2 \times 10^{\frac{NEXT_{conn}}{20}} \right) \text{dB} \quad (5)$$

**Table 11-3 Pair-to-pair NEXT loss for channel test configuration (worst pair-to-pair)**

Frequency (MHz)	Category 3 (dB)	Category 5e (dB)
1.0	39.1	>60
4.0	29.3	53.5
8.0	24.3	48.6
10.0	22.7	47.0
16.0	19.3	43.6
20.0	--	42.0
25.0	--	40.3
31.25	--	38.7
62.5	--	33.6
100.0	--	30.1

$$NEXT_{permanentlink} = -20 \log \left( 10^{\frac{-NEXT_{cable}}{20}} + 10^{\frac{-NEXT_{conn}}{20}} \right) \text{dB} \quad (6)$$

**Table 11-4 Pair-to-pair NEXT loss for permanent link test configuration (worst pair-to-pair)**

Frequency (MHz)	Category 3 (dB)	Category 5e (dB)
1.0	40.1	>60
4.0	30.7	54.8
8.0	25.9	50.0
10.0	24.3	48.5
16.0	21.0	45.2
20.0	--	43.7
25.0	--	42.1
31.25	--	40.5
62.5	--	35.7
100.0	--	32.3

#### 11.2.4.6 PSNEXT loss

PSNEXT loss takes into account the combined crosstalk (statistical) on a receive pair from all near-end disturbers operating simultaneously. The PSNEXT loss is calculated in accordance with ASTM D4566 as a power sum on a selected pair from all other pairs as shown in equation (7) for the case of 4-pair cable.

$$PSNEXT = -10 \log \left( 10^{-X1/10} + 10^{-X2/10} + 10^{-X3/10} \right) \text{dB} \quad (7)$$

where:

$X1$ ,  $X2$ ,  $X3$  are the pair-to-pair crosstalk measurements in dB between the selected pair and the other three pairs.

NOTE – For channel and permanent link power sum calculations, it is assumed that the pair-to-pair connecting hardware NEXT loss requirements of ANSI/TIA/EIA-568-B.2 correlate to an equivalent PSNEXT loss performance of  $40-20 \log(f/100)$ .

For all frequencies from 1 to 100 MHz, category 5e cabling PSNEXT loss shall meet the values determined using equations (8) and (9) for the channel and permanent link, respectively. PSNEXT loss values greater than 57 dB shall revert to a requirement of 57 dB. PSNEXT loss is not a required category 3 parameter. The values in tables 11-5 and 11-6 are provided for information only.

$$PSNEXT_{channel} \geq -20 \log \left( 10^{\frac{-PSNEXT_{cable}}{20}} + 2 \times 10^{\frac{-PSNEXT_{conn}}{20}} \right) \text{ dB} \quad (8)$$

**Table 11-5 Category 5e channel PSNEXT loss**

Frequency (MHz)	Category 5e (dB)
1.0	>57
4.0	50.5
8.0	45.6
10.0	44.0
16.0	40.6
20.0	39.0
25.0	37.3
31.25	35.7
62.5	30.6
100.0	27.1

PSNEXT loss values greater than 57 dB shall revert to a requirement of 57 dB.

$$PSNEXT_{permanent\_link} \geq -20 \log \left( 10^{\frac{-PSNEXT_{cable}}{20}} + 10^{\frac{-PSNEXT_{conn}}{20}} \right) \text{ dB} \quad (9)$$

**Table 11-6 Category 5e permanent link PSNEXT loss**

Frequency (MHz)	Category 5e (dB)
1.0	>57
4.0	51.8
8.0	47.0
10.0	45.5
16.0	42.2
20.0	40.7
25.0	39.1
31.25	37.5
62.5	32.7
100.0	29.3

PSNEXT loss values greater than 57 dB shall revert to a requirement of 57 dB.

#### 11.2.4.7 Pair-to Pair ELFEXT and FEXT loss parameters

FEXT loss is a measure of the unwanted signal coupling from a transmitter at the near-end into another pair measured at the far-end. Pair-to-pair ELFEXT is expressed in dB as the difference between the

measured FEXT loss and the insertion loss of the disturbed pair. PSELFEXT is a computed ratio that takes into account the combined crosstalk on the receive pair at the far-end from all of the near-end disturbers operating simultaneously. FEXT loss or pair-to-pair ELFEXT shall be measured for all pair combinations for components and cabling, in accordance with ASTM D4566 FEXT measurement procedure and in accordance with annex D of ANSI/TIA/EIA-568-B.2.

NOTE – For the permanent link and channel calculated requirements, the cable and connecting hardware performance equations are used.

For all frequencies from 1 to 100 MHz, the category 5e worst pair-to-pair ELFEXT of cabling shall meet the values determined using equations (10) and (11) for the channel and permanent link, respectively. The worst pair-to-pair ELFEXT of cabling is not a required category 3 measurement parameter. The values in tables 11-7 and 11-8 are provided for information only.

$$ELFEXT_{channel, pair-to-pair} \geq -20 \log \left( 10^{\frac{-ELFEXT_{cable, pair-to-pair}}{20}} + 4 \times 10^{\frac{-FEXT_{connector, pair-to-pair}}{20}} \right) \text{dB} \quad (10)$$

**Table 11-7 Category 5e channel pair-to-pair ELFEXT, worst pair-to-pair**

Frequency (MHz)	Category 5e (dB)
1.0	57.4
4.0	45.4
8.0	39.3
10.0	37.4
16.0	33.3
20.0	31.4
25.0	29.4
31.25	27.5
62.5	21.5
100.0	17.4

$$ELFEXT_{permanent\_link} \geq -20 \log \left( 10^{\frac{ELFEXT_{cable, pair-pair}}{20}} + 3 * 10^{\frac{FEXT_{connector, pair-pair}}{20}} \right) \text{dB} \quad (11)$$

**Table 11-8 Category 5e permanent link pair-to-pair ELFEXT, worst pair-to-pair**

Frequency (MHz)	Category 5e (dB)
-----------------	------------------

1.0	58.6
4.0	46.6
8.0	40.6
10.0	38.6
16.0	34.5
20.0	32.6
25.0	30.7
31.25	28.7
62.5	22.7
100.0	18.6

#### 11.2.4.8 Cabling PSELFEXT

For all frequencies from 1 to 100 MHz, the category 5e PSELFEXT of the cabling shall be measured in accordance with annex E of ANSI/TIA/EIA-568-B.2 and shall meet the values determined using equations (12) and (13) for the channel and permanent link, respectively. PSELFEXT is not a required category 3 measurement parameter. The values in tables 11-9 and 11-10 are provided for information only.

NOTE - For channel and permanent link power sum calculations, it is assumed that the pair-to-pair connecting hardware FEXT loss requirements of this document correlate to an equivalent PSFEXT loss performance of  $32.1-20\log(f/100)$ , where  $f$  is the frequency in MHz.

$$PSELFEXT_{\text{channel}} \geq -20 \log \left( 10^{\frac{-PSELFEXT_{\text{cable}}}{20}} + 4 * 10^{\frac{-PSFEXT_{\text{conn}}}{20}} \right) \text{dB} \quad (12)$$

**Table 11-9 Category 5e channel PSELFEXT**

Frequency (MHz)	Category 5e (dB)
1.0	54.4
4.0	42.4
8.0	36.3
10.0	34.4
16.0	30.3
20.0	28.4
25.0	26.4
31.25	24.5
62.5	18.5
100.0	14.4

$$PSELFEXT_{\text{permanent\_link}} \geq -20 \log \left( 10^{\frac{-PSELFEXT_{\text{cable}}}{20}} + 3 * 10^{\frac{-PSFEXT_{\text{conn}}}{20}} \right) \text{dB} \quad (13)$$

**Table 11-10 Category 5e permanent link PSELFEXT**

<b>Frequency (MHz)</b>	<b>Category 5e (dB)</b>
1.0	55.6
4.0	43.6
8.0	37.5
10.0	35.6
16.0	31.5
20.0	29.6
25.0	27.7
31.25	25.7
62.5	19.7
100.0	15.6

### 11.2.4.9 Cabling return loss

Return loss is a measure of the reflected energy caused by impedance variations in the cabling system. For all frequencies from 1 to 100 MHz, the category 5e minimum return loss of the cabling shall be measured in accordance with annex E of ANSI/TIA/EIA-568-B.2 and shall meet or exceed the values shown in tables 11-11 and 11-13. Cabling return loss is not a required category 3 measurement parameter. The values in tables 11-12 and 11-14 are provided for information only.

**Table 11-11 Category 5e channel return loss**

Frequency (MHz)	Category 5e (dB)
$1 \leq f < 20$	17
$20 \leq f \leq 100$	$17 - 10\log(f/20)$
NOTE – $f$ is the frequency in MHz	

(14)

**Table 11-12 Category 5e channel return loss**

Frequency (MHz)	Category 5e (dB)
1.0	17.0
4.0	17.0
8.0	17.0
10.0	17.0
16.0	17.0
20.0	17.0
25.0	16.0
31.25	15.1
62.5	12.1
100.0	10.0

**Table 11-13 Category 5e permanent link return loss**

Frequency (MHz)	Category 5e (dB)
$1 \leq f < 20$	19
$20 \leq f \leq 100$	$19 - 10\log(f/20)$
NOTE – $f$ is the frequency in MHz	

(15)

**Table 11-14 Category 5e permanent link return loss**

Frequency (MHz)	Category 5e (dB)
1.0	19.0
4.0	19.0
8.0	19.0
10.0	19.0
16.0	19.0
20.0	19.0
25.0	18.0
31.25	17.1
62.5	14.1
100.0	12.0

#### 11.2.4.10 Propagation delay

Propagation delay is the time it takes for a signal to propagate from one end to the other. Propagation delay shall be measured in accordance with annex D of ANSI/TIA/EIA-568 B.2. In determining the channel and permanent link propagation delay, the propagation delay contribution of connecting hardware is assumed to not exceed 2.5 ns from 1 MHz to 100 MHz.

The maximum propagation delay for all category channel configurations shall not exceed 555 ns measured at 10 MHz.

The maximum propagation delay for all category permanent link configurations shall not exceed 498 ns measured at 10 MHz.

#### 11.2.4.11 Delay skew

Delay skew is a measurement of the signaling delay difference from the fastest pair to the slowest. Delay skew shall be measured in accordance with annex D of ANSI/TIA/EIA-568-B.2. For each installed mated connection, the delay skew is assumed not to exceed 1.25 ns.

The maximum delay skew for all category channel configurations shall be less than 50 ns. The maximum delay skew for all category permanent link configurations shall not exceed 44 ns.

### 11.3 Optical fiber transmission performance and test requirements

#### 11.3.1 Purpose

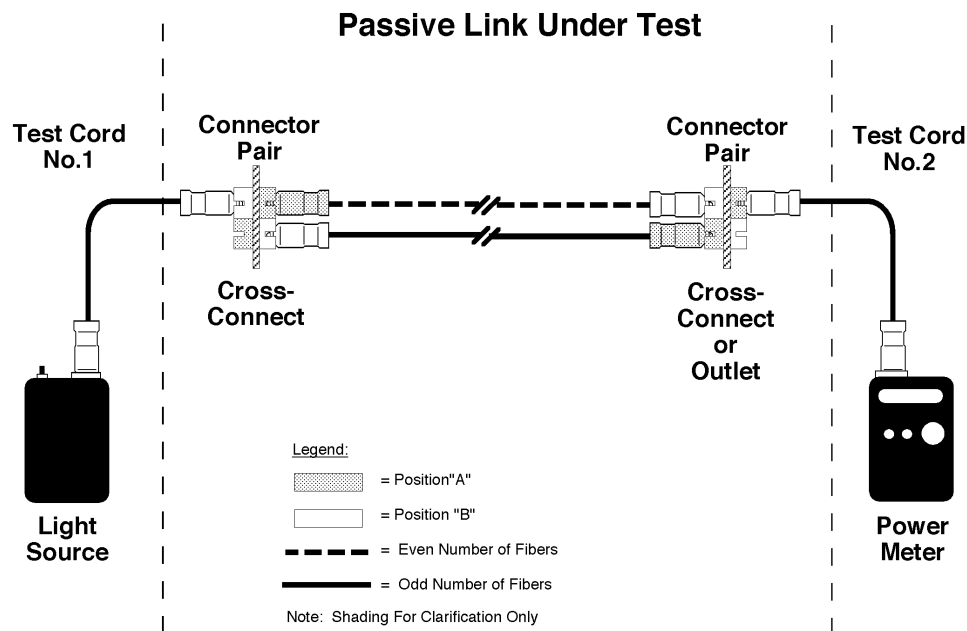
This subclause describes the minimum recommended performance test criteria for an optical fiber cabling system installed in compliance with this Standard. The purpose of this subclause is to provide users with recommended field test procedures and acceptance values. This subclause will address the



testing and link performance requirements of singlemode and multimode optical fiber systems in the horizontal and backbone infrastructure.

### 11.3.2 Link segment

An optical fiber link segment is the passive cabling, to include cable, connectors, and splices (if present), between two optical fiber connecting hardware termination points as indicated in figure 11-5. A typical horizontal link segment is from the telecommunications outlet/connector to the horizontal cross-connect. There are three typical backbone link segments: main cross-connect to intermediate cross-connect, main cross-connect to horizontal cross-connect, and intermediate cross-connect to horizontal cross-connect. Additionally, centralized optical fiber cabling provides a link from the telecommunications outlet to the centralized cross-connect through a splice or interconnect in the telecommunications room. As figure 11-5 illustrates, the test includes the representative connector performance at the connecting hardware associated with the mating of patch cords. It does not, however, include the performance of the connector at the equipment interface.



**Figure 11-5 Optical fiber passive link**

#### NOTES

1 – Optical power budgets specified in application standards, such as FDDI, 10BASE-F, and others, include the optical loss of the connector at the equipment interface.

2 – If the desired system link is created by the concatenation of two (2) or more passive link segments, i.e., a cross-connect patch cord linking cross-connects together, then the expected attenuation for the system link is the sum of the concatenated passive link segment attenuation.

### 11.3.3 Link segment performance

The single performance parameter necessary for performance testing, when installing components compliant with this Standard, is link attenuation. Bandwidth (multimode) and dispersion (singlemode)

are important performance parameters, but because they can not be adversely affected by installation practices, they should be tested by the fiber manufacturer and do not require testing in the field.

The acceptable link attenuation for a recognized horizontal optical fiber cabling system is based on the maximum 90 m (295 ft) distance. The link attenuation equation in subclause 11.3.3.4 is provided to determine acceptable link performance for multimode and singlemode backbone cabling systems. This equation calculates link attenuation for backbone link segments based upon fiber type, cable type, wavelength, link distance and number of splices. Additionally, graphs of link attenuation are included in figures 11-6 and 11-7.

Link attenuation has been based on the connectivity requirements of this Standard and the use of the One Reference Jumper Method specified by ANSI/TIA/EIA-526-14-A, Method B and ANSI/TIA/EIA-526-7, Method A.1. The user should follow the procedures established by these standards to accurately conduct performance testing.

Short link lengths of multimode optical fiber may appear to have higher than expected attenuation due to the power lost in the high-order modes. To remove high-order mode transient losses from multimode optical fiber measurements when using a source that excites these transient high-order modes, the reference jumper should be wrapped in five non-overlapping turns around a smooth round mandrel (rod) during the reference calibration of the source to the detector and for all loss measurements. The mandrel diameter depends on fiber core size and shall be as specified in table 11-15.

**Table 11-15 Mandrel diameters for multimode optical fiber core sizes**

<b>Fiber core size (<math>\mu\text{m}</math>)</b>	<b>Mandrel diameter for buffered fiber (mm [in])</b>	<b>Mandrel diameter for 3 mm (0.12 in) jacketed cable (mm [in])</b>
50	25 (1.0)	22 (0.9)
62.5	20 (0.8)	17 (0.7)

Link attenuation does not include any active devices or passive devices other than cable, connectors, and splices (i.e., link attenuation does not include such devices as optical bypass switches, couplers, repeaters or optical amplifiers).

### **11.3.3.1 Horizontal link measurement**

The horizontal optical fiber cabling link segments need to be tested at only one wavelength. Because of the short length of cabling (90 m [295 ft] or less), attenuation deltas due to wavelength are insignificant. The horizontal link should be tested at 850 nm or 1300 nm in one direction in accordance with ANSI/EIA/TIA-526-14-A, Method B, One Reference Jumper. The attenuation test results shall be less than 2.0 dB. This value is based on the loss of two connector pairs, one pair at the telecommunications outlet/connector and one pair at the horizontal cross-connect, plus 90 m (295 ft) of optical fiber cable.

For open office cabling implemented with a consolidation point, the attenuation test results shall be less than 2.75 dB when testing between the horizontal cross-connect and the telecommunications outlet/connector. For open office cabling implemented with the multi-user telecommunications outlet assembly, the attenuation test results shall be less than 2.0 dB.

### **11.3.3.2 Backbone link measurement**

The backbone optical fiber cabling link segment shall be tested in at least one direction at both operating wavelengths to account for attenuation deltas associated with wavelength. Singlemode backbone links should be tested at 1310 nm and 1550 nm in accordance with ANSI/TIA/EIA-526-7,

Method A.1, One Reference Jumper. Multimode backbone links shall be tested at 850 nm and 1300 nm in accordance with ANSI/EIA/TIA-526-14A, Method B, One Reference Jumper. Because backbone length and the potential number of splices vary depending upon site conditions, the link attenuation equation (16) should be used to determine acceptance values based upon this Standard's component requirement at each of the applicable wavelengths.

### 11.3.3.3 Centralized optical fiber link measurement

The centralized optical fiber cabling link shall be tested at 850 nm or 1300 nm in one direction. Because of the short length of cabling (300 m [984 ft] or less), attenuation deltas due to wavelength are insignificant. The centralized link shall be tested at 850 nm or 1300 nm (850 nm recommended) in one direction in accordance with ANSI/EIA/TIA-526-14A, Method B, One Reference Jumper. The attenuation test results shall be less than 3.3 dB. This value is based on the loss of three connector pairs, one pair at the telecommunications outlet/connector, one pair at the interconnect center in the telecommunications room, and one pair at the centralized cross-connect, plus 300 m (984 ft) of optical fiber cable.

For centralized optical fiber cabling link segments implemented in conjunction with open office cabling with a consolidation point, the attenuation results shall be less than 4.1 dB.

### 11.3.3.4 Link attenuation equation and graphs

Link attenuation is calculated as:

$$\text{Link Attenuation} = \text{Cable Attenuation} + \text{Connector Insertion loss} + \text{Splice Insertion loss} \quad (16)$$

where:

$$\text{Cable Attenuation (dB)} = \text{Attenuation Coefficient (dB/km)} \times \text{Length (km)}$$

Attenuation Coefficients are:

- 3.5 dB/km @ 850 nm for multimode
- 1.5 dB/km @ 1300 nm for multimode
- 0.5 dB/km @ 1310 nm for singlemode outside plant cable
- 0.5 dB/km @ 1550 nm for singlemode outside plant cable
- 1.0 dB/km @ 1310 nm for singlemode inside plant cable
- 1.0 dB/km @ 1550 nm for singlemode inside plant cable

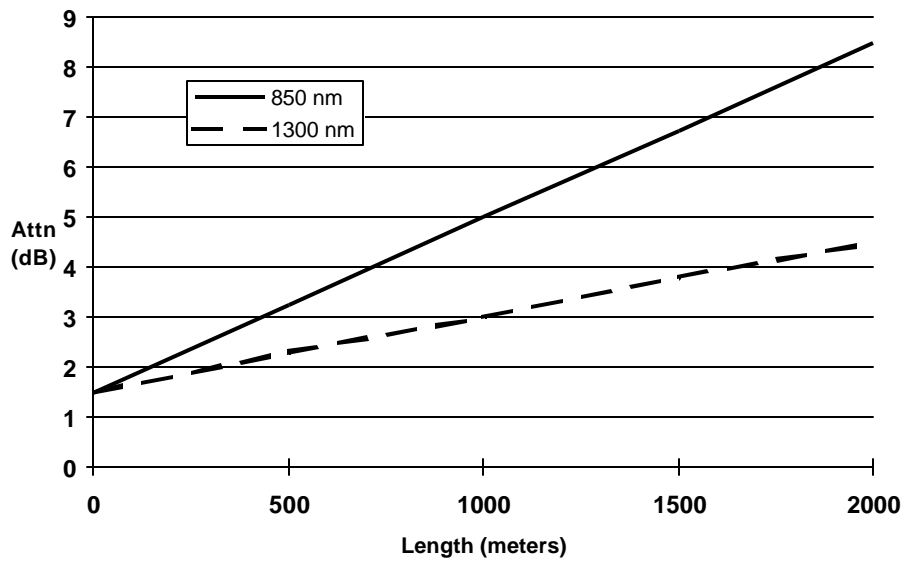
$$\text{Connector Insertion loss (dB)} = \text{number of connector pairs} \times \text{connector loss (dB)}$$

Example:  
 $= 2 \times 0.75 \text{ dB}$   
 $= 1.5 \text{ dB}$

$$\text{Splice Insertion loss (dB)} = \text{number of splices (S)} \times \text{splice loss (dB)}$$

Example:  
 $= S \times 0.3 \text{ dB}$

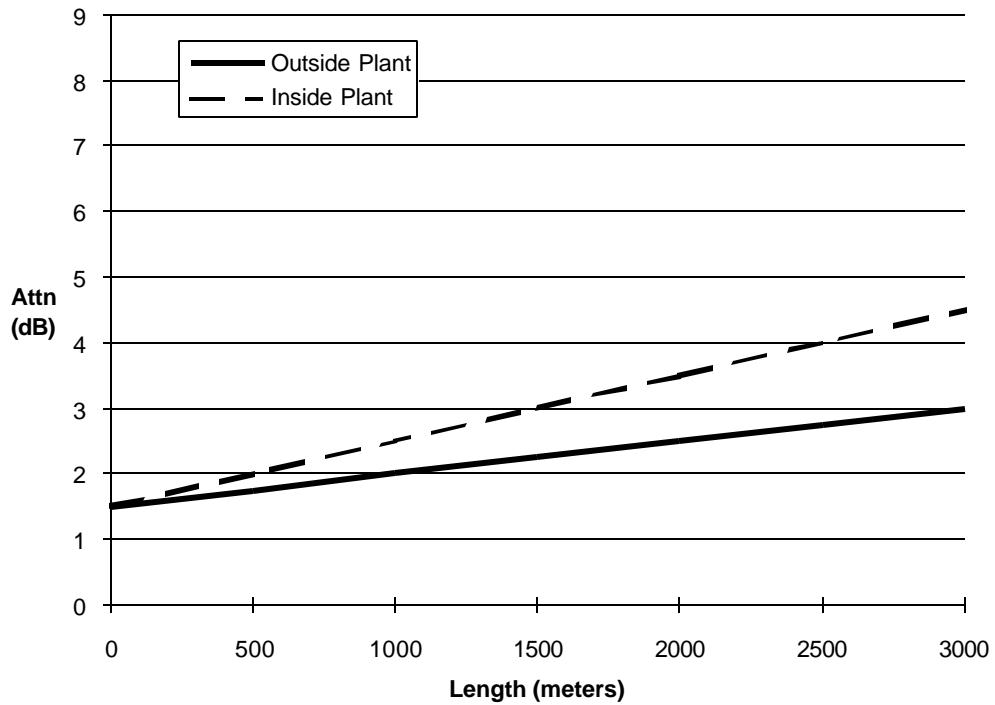
Figure 11-6 is a graph of 62.5/125  $\mu\text{m}$  or 50/125  $\mu\text{m}$  backbone cabling depicting link attenuation based on wavelength and distance and two connector pairs. The graph does not account for any splice loss. If the link contains splices, then add 0.3 dB for each splice in the link.



**Figure 11-6 62.5/125 mm or 50/125 mm backbone cabling link attenuation based on distance**

For example, a horizontal cross-connect (HC) to intermediate cross-connect (IC) multimode link segment of the allowable 300 m (984 ft) length without any splices shall have attenuation test results of less than or equal to 2.6 dB at 850 nm and 2.0 dB at 1300 nm. Yet in another example, an intermediate cross-connect (IC) to main cross-connect (MC) multimode link segment of the allowable 2 km (6560 ft) length without any splices shall have attenuation test results of less than or equal to 8.5 dB at 850 nm and 4.5 dB at 1300 nm.

Figure 11-7 is a graph of singlemode backbone cabling depicting link attenuation based on cable type (i.e., outside plant or inside plant), distance and two connector pairs. The graph does not account for any splice loss. If the link contains splices, then add 0.3 dB for each splice in the link. If the link consists of both inside and outside plant cables, then the equation should be used based on the length of each of the cable types.



**Figure 11-7 Singlemode backbone cabling link attenuation based on distance**

For example, a horizontal cross-connect (HC) to intermediate cross-connect (IC) singlemode inside plant link segment of the allowable 300 m (984 ft) length without any splices shall have attenuation test results of less than or equal to 1.8 dB at 1310 nm and 1550 nm. Yet in another example, an intermediate cross-connect (HC) to main cross-connect (MC) singlemode outside plant link segment of the allowable 3000 m (9840 ft) length without any splices shall have attenuation test results of less than or equal to 3.0 dB at 1310 nm and 1550 nm.

## **ANNEX A (NORMATIVE) CENTRALIZED OPTICAL FIBER CABLING**

This annex is normative and is considered part of this Standard.

### **A.1 Introduction**

Many single tenant users of high performance optical fiber are implementing data networks with centralized electronics versus distributed electronics in the building. Centralized optical fiber cabling is designed as an alternative to the optical cross-connection located in the telecommunications room when deploying recognized optical fiber cable in the horizontal in support of centralized electronics.

Centralized cabling provides connections from work areas to centralized cross-connects by allowing the use of pull-through cables, an interconnect, or splice in the telecommunications room.

The horizontal cross-connection as specified in clause 4, and clause 7 of this Standard and subclause 5.4 of ANSI/TIA/EIA-568-B.3 provides the user with maximum flexibility, specifically in the deployment of distributed electronics or in multi-tenant buildings.

Careful planning and implementation of centralized optical fiber cabling will help assure that the user maintains adequate flexibility and manageability with the cabling network. Users of this Standard are advised to consult with equipment manufacturers and system integrators to determine the suitability of these requirements for specific networking applications.

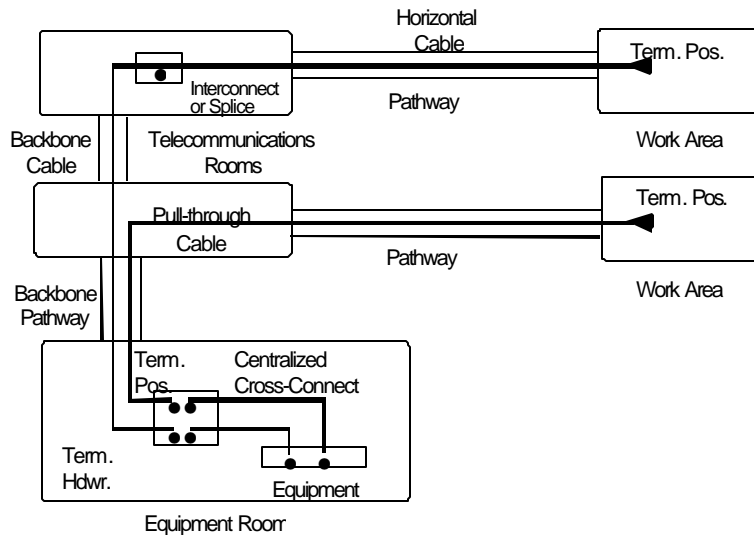
### **A.2 Applicability**

The guidelines and requirements for centralized optical fiber cabling networks are intended for those single-tenant users who desire to deploy centralized electronics rather than distributed electronics and want an alternative to locating the cross-connection in the telecommunications room.

This annex specifies requirements for the connecting hardware and general implementation guidelines that will ensure adequate flexibility and manageability of optical fiber links including the ability to migrate to a cross-connection located in the telecommunications room, if required.

### **A.3 General guidelines**

This annex specifies the use of either pull-through cables, an interconnect, or splice in the telecommunications room. The use of an interconnection between the backbone and horizontal cabling is recognized to offer increased flexibility, manageability, and ease to migrate to a cross-connection (see figure A-1).



**Figure A-1 Centralized optical fiber cabling**

The specifications of ANSI/TIA/EIA-569-A shall be followed.

The maximum horizontal cabling distance is as specified in clause 4.

The installation shall be limited to 300 m (984 ft) consisting of the combined length of the horizontal, intrabuilding backbone, and patch cords.

Centralized cabling implementations shall be located within the same building as the work areas served. The administration of moves and changes shall be performed at the centralized cross-connect. The addition and removal of horizontal links should be performed at the telecommunications room. Pull-through cables are continuous sheath cables that are pulled through a telecommunications room from the centralized cross-connect to the telecommunications outlet/connector. The pull-through cable length shall be less than or equal to 90 m (295 ft). Pull-through cables shall meet the same requirements of recognized horizontal optical fiber cable per clause 4 of ANSI/TIA/EIA-568-B.3.

Centralized cabling design shall allow for migration (in part or in total) of the pull-through, interconnect, or splice implementation to a cross-connection implementation. Sufficient space shall be left in the telecommunications room to allow for the addition of patch panels needed for the migration of the pull-through, interconnect, or splice to a cross-connection. Sufficient cable slack shall exist in the telecommunications room to allow movement of the cables when migrating to a cross-connection.

**NOTE** – Specifications on pull-through implementations apply equally to all media types. Cross-connects for different media types are required by subclause 5.4 to be in the same location.

Slack may be stored as cable or unjacketed fiber (buffered or coated). Slack storage shall provide bend radius control so that cable and fiber bend radius limitations are not violated. Cable slack may be stored within enclosures or on the walls of the telecommunications room. Fiber slack shall be stored in protective enclosures.

Centralized cabling design shall allow for the addition and removal of horizontal and intrabuilding backbone fibers. The layout of both rack-mount and wall-mount termination hardware should accommodate modular growth in an orderly manner.

The intrabuilding backbone subsystem should be designed with sufficient spare capacity to service additional outlet/connectors from the centralized cross-connect without the need to pull additional intrabuilding backbone cables. The intrabuilding backbone fiber count should be sized to deliver present and future applications to the maximum work area density within the area served by the telecommunications room. Generally, two fibers are required for each application delivered to a work area.

Centralized cabling shall support the labeling requirements of ANSI/TIA/EIA-606. In addition, telecommunications room splice and interconnect hardware shall be labeled with unique identifiers on each termination position. Field color-coding is not used at the interconnect or splice. The centralized cross-connect termination positions connected to telecommunications outlet/connector shall be labeled as a blue field. The blue field shall move to the telecommunications room for each circuit that is converted to a cross-connection in the telecommunications room.

Centralized cabling shall be implemented to ensure the correct fiber polarity as specified in subclause 10.3.2 (i.e., A-B orientation at the telecommunications outlet/connector and B-A orientation at the centralized cross-connect).



## **ANNEX B (INFORMATIVE) SHARED SHEATH GUIDELINES FOR MULTIPAIR UTP CABLES**

This annex is informative only and is not part of this Standard.

### **B.1 General**

Shared sheath and distance guidelines described in this annex are typical, and not intended to cover every combination of applications. It is recommended that the user consult with equipment manufacturers, applications standards, and system providers, for additional information. For additional guidelines regarding distance, see subclause 5.5.1.

### **B.2 Shared sheath guidelines**

There are many issues to consider when deciding which applications and how many systems can share a common 25-pair binder group in a multipair UTP cable. Some of the most important considerations are:

- a) transmit amplitudes;
- b) signal;
- c) robustness of protocols; and,
- d) receiver sensitivity.

In general, applications using totally different frequency ranges tend not to interfere with one another. If receiver bandwidths are appropriately restricted, then there is little chance for crosstalk from one system to interfere with another. The main problem occurs when systems with a common bandwidth share a common binder group in a multipair cable. In this case, one has to know additional information such as the type of transmission (bursty, continuous, synchronized or random). This information should be taken into consideration before making a decision on whether or not to use the same binder group for such systems. Once this is known, appropriate guidelines regulating distances and the number of systems in a multipair binder group can be determined. The best example of this is the 10BASE-T standard that accounted for all of the effects listed herein and determined that 12 systems could share a common binder group for category 3 multipair UTP cabling. Some examples of shared sheath restrictions for specific applications using category 3 binder groups are:

- a) EIA232D and ISDN applications should be on separate binder groups.
- b) 3270 type signals converted to balanced 100-ohm twisted-pair should not share the same binder group as 10BASE-T. (Many 3270 baluns have poor rejection capabilities at higher frequencies).
- c) Signals from hosts with multiple controllers should not share the same binder group (signals from the same controller can share a binder group).
- d) Signals with significantly different power levels should not share the same binder group.

Shared sheath performance using category 5e cabling is considerably better than category 3 for applications with data rates up to 10 Mb/s.

## ANNEX C (INFORMATIVE) OTHER CABLE SPECIFICATIONS

This annex is informative only and is not part of this Standard.

### C.1 General

This annex discusses some additional cables that may be of interest. The descriptions given are brief and do not include full transmission specifications. In some cases, the reason for not including the cables in this Standard is discussed.

These cables are included because they can be used effectively in some cases. Many have large installed bases. In addition, some of the cables, properly configured, can actually offer performance equivalent to the recognized cables. It is the user's responsibility to make certain that these cables provide adequate performance.

### C.2 Horizontal cabling

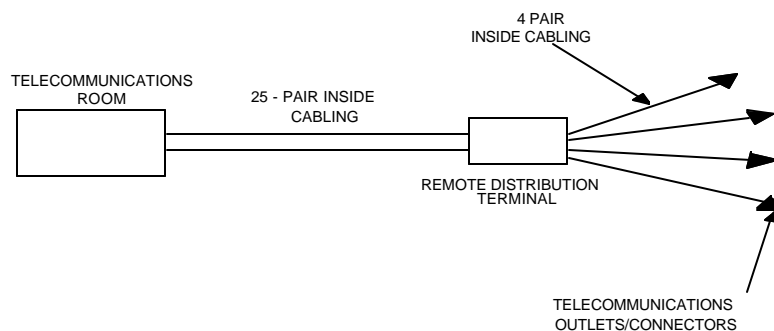
#### C.2.1 Multipair 100-ohm twisted-pair cables

Multipair inside cabling has been traditionally used for voice services between the telecommunications room and a remote distribution termination. A typical configuration is illustrated in figure C-1.

Although such an arrangement may provide installation efficiencies, it should not be used for the general case. Some services will co-exist, but the variety and demands of modern voice and data networks make it difficult to characterize and guarantee performance. In commercial buildings where occupancy is by more than one tenant, there would be the possibility of one user's system interfering with another's. If interference occurred, then finding the source and resolving the problem would be difficult and time consuming.

Transmission categories for multipair cables used in such configurations should be identical to those of multipair backbone cables as specified in ANSI/TIA/EIA-568.B.2.

Consequently, the use of multipair cables for horizontal distribution should be undertaken only as a special case considering system engineering guidelines.



**Figure C-1 Multipair cable configuration**

### **C.2.2 75-Ohm coaxial cable**

This media is effective in video and broadband applications from 5MHz to 1GHz. Standards to reference include IEEE 802.4 (broadband applications), IEEE 802.7 specifications, ANSI T1.404 (DS3), and CATV applications.

### **C.2.3 50-Ohm coaxial cable**

This media should meet the requirements specified in IEEE 802.3 (10BASE2).

## **C.3 Backbone cabling**

### **C.3.1 100-Ohm STP cable**

The cable used in the backbone cabling system generally contains several pairs. The cable may have an overall shield. Internal shielding such as individual pair shields or "D" or "T" screen compartment shielding are sometimes used.

The shield or shields should be grounded. The equipment manufacturer recommendations should be followed concerning specific installations. It is not desirable that the shield be terminated on connector pins. Shield continuity should be provided external to the connector housing.

### **C.3.2 Other multimode optical fiber cables**

Four (4) multimode optical fiber sizes have been recognized in an earlier ANSI/EIA-492-A000 standard. No multimode optical fiber is optimum for all applications. However, the 62.5/125  $\mu\text{m}$  or 50/125  $\mu\text{m}$  graded index optical fiber is best for applications perceived at this time. Widespread use of this optical fiber size will permit the transportability of terminals within and between buildings.

Other multimode fibers are 200/230  $\mu\text{m}$  step and graded index optical fiber, and 100/140  $\mu\text{m}$  graded index optical fiber. Advantages claimed for 200/230  $\mu\text{m}$  and 100/140  $\mu\text{m}$  optical fiber are more power coupled into the optical fiber from LED sources and less precision required for connectors and splices. For specialized systems applications, tradeoff analysis may indicate that one of these latter two (2) sizes may be optimum. However, such special applications do not meet the requirements of this Standard.

### **C.3.3 75-Ohm coaxial cable**

This media is effective in video and broadband applications from 5MHz to 1GHz. Standards to reference include IEEE 802.4 broadband applications, IEEE 802.7 specifications, ANSI T1.404 (DS3) and CATV applications.

For CATV backbone applications semi-rigid trunk cables are often utilized. These cables are available in sizes from 12.7 mm (0.500 in) up to 28.6 mm (1.125 in) in diameter over the solid aluminum outer conductor. A plastic jacket over the outer conductor is optional.

### **C.3.4 50-Ohm coaxial cable**

This media should meet the requirements specified in IEEE 802.3 (10BASE5).

## ANNEX D (INFORMATIVE) CATEGORY 5 CABLING TRANSMISSION

This annex is informative only and is not part of this Standard.

### D.1 General

This annex provides the cabling transmission performance and test requirements for 100-ohm category 5 basic links and channels as originally specified in ANSI/TIA/EIA-568-A, TIA TSB76, and TIA TSB95. Field test instruments used to verify category 5 performance should be compliant to the Level IIe requirements specified in ANSI/TIA/EIA-568-B.2.

### D.2 Measurement precautions

When field testing installed cabling, it is possible that Fail, Pass\*, or Fail \* results will be reported against the basic link or channel ELFEXT or return loss limits. These conditions may occur when the performance of the cabling components or the accuracy of the test instrumentation is close to the specified ELFEXT or return loss limits and worst case conditions in cabling topology are present. Corrective action may consist of verifying compliance with installation practices, verifying test instrument accuracy performance and settings, replacing minimally complying components with others providing better performance or reducing the number of connections in the link (e.g., replacing cross-connections with interconnections). See subclause D.4.11 for field failure mitigation procedures.

### D.3 Test configurations

The category 5 channel test should be configured in accordance with subclause 11.2.3. The category 5 basic link test configuration should be in accordance with figure D-1. The difference between the basic link configuration (see figure D-1) and permanent link configuration (see figure 11-2) is that the basic link measurement includes the test equipment cord, whereas the permanent link does not.

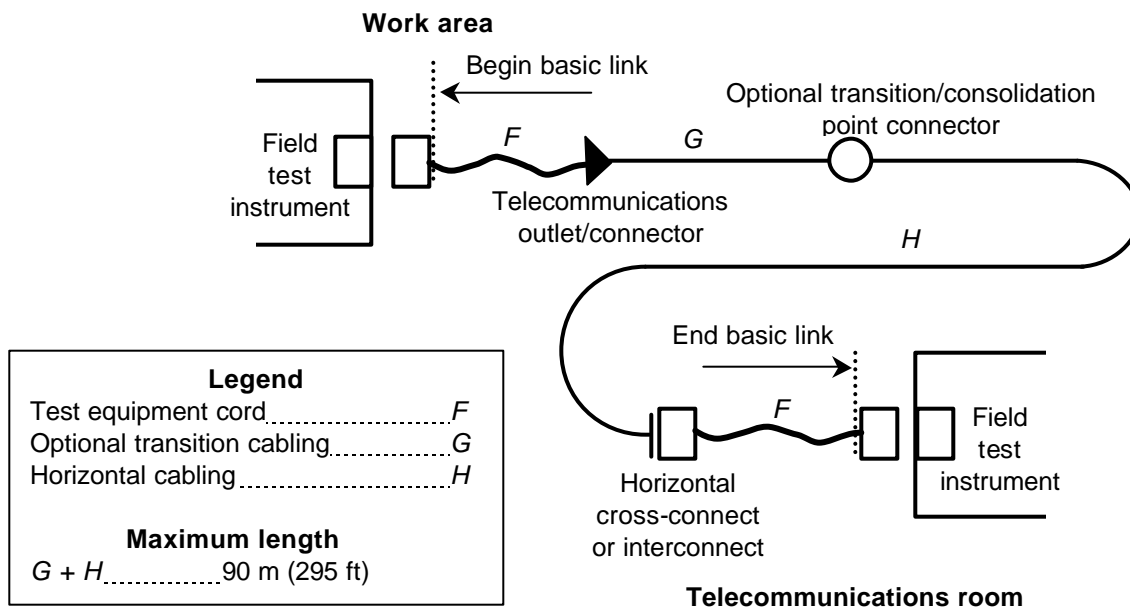


Figure D-1 Schematic representation of a basic link test configuration

## D.4 Test parameters

### D.4.1 Wire map

Wire map should be tested in accordance with and meet the requirements of subclause 11.2.4.2.

### D.4.2 Length

Length should be tested in accordance with and meet the requirements of subclause 11.2.4.3.

### D.4.3 Insertion loss

Insertion loss should be tested in accordance with subclause 11.2.4.4. Examples of the worst-case insertion loss at selected frequencies for the channel and basic link are shown in tables 11-1 and D-1 respectively. These values are provided for information only.

NOTE – The basic link assumes a two-connector topology.

**Table D-1 Category 5 insertion loss @ 20 °C for basic link test configuration**

Length of horizontal cable: 90 m (295 ft)

Length of equipment cords: 4 m (13 ft)

Frequency (MHz)	Category 5 (dB)
1.0	2.1
4.0	4.0
8.0	5.7
10.0	6.3
16.0	8.2
20.0	9.2
25.0	10.3
31.25	11.5
62.5	16.7
100.0	21.6

### D.4.4 Pair-to-pair NEXT loss

Pair-to-pair NEXT loss is a measure of signal coupling from one pair to another within a 100-ohm twisted-pair cabling link and is derived from swept/stepped frequency measurements or equivalent. A balanced input signal is applied to a disturbing pair at the near-end of the link while the induced differential signal on the disturbed pair is measured at the near-end. Pair-to-pair NEXT loss should be measured in accordance with annex E of ANSI/TIA/EIA-568-B.2 and should be better than the worst case values determined by:

$$NEXT(f) = -20 \log_{10} \sum 10^{-Ni/20}, i = 1, 2, \dots, n \text{ dB} \quad (\text{D-1})$$

where  $Ni$  = pair-to-pair NEXT loss of component  $i$  at frequency  $f$ ; and,  $n$  = number of components in the basic link or channel at the near-end.

The following equations are used to determine the values in tables D-1 and D-2 respectively:

$$NEXT_{channel} = -20 \log \left( 10^{\frac{NEXT_{cable}}{20}} + 2 \times 10^{\frac{NEXT_{conn}}{20}} \right) \text{ dB} \quad (\text{D-2})$$

$$NEXT_{basiclink} = -20\log\left(10^{\frac{-NEXT_{cable}}{20}} + 10^{\frac{-NEXT_{conn}}{20}}\right) \text{dB} \quad (\text{D-3})$$

where:

$NEXT_{cable}$  is the pair-to-pair NEXT loss of 100-ohm twisted-pair category 5 horizontal cable as defined in ANSI/TIA/EIA-568-B.2.

and:

$NEXT_{conn}$  is the pair-to-pair NEXT loss of 100-ohm twisted-pair category 5 connecting hardware as defined in ANSI/TIA/EIA-568-B.2.

All pair combinations should be measured. Table D-2 gives values of worst-pair pair-to-pair NEXT loss for a channel at specific frequencies in the band of interest. The test configuration for the channel includes two connections at the near-end. These values are provided for information only.

**Table D-2 Category 5 pair-to-pair NEXT loss for channel test configuration (worst pair-to-pair)**

Frequency (MHz)	Category 5 (dB)
1.0	>60
4.0	50.6
8.0	45.6
10.0	44.0
16.0	40.6
20.0	39.0
25.0	37.4
31.25	35.7
62.5	30.6
100.0	27.1

NEXT loss values greater than 60 dB should revert to a requirement of 60 dB.

Table D-3 gives values of worst pair-to-pair NEXT loss for a basic link at specific frequencies in the band of interest. The test configuration for the basic link includes one (1) connection at the near-end. These values are provided for information only.

**Table D-3 Category 5 pair-to-pair NEXT loss for basic link test configuration (worst pair-to-pair)**

Frequency (MHz)	Category 5 (dB)
1.0	>60
4.0	51.8
8.0	47.1
10.0	45.5
16.0	42.3
20.0	40.7
25.0	39.1
31.25	37.6
62.5	32.7
100.0	29.3

NEXT loss values greater than 60 dB should revert to a requirement of 60 dB.

#### D.4.5 Cabling return loss

The minimum return loss of the cabling, should meet or exceed the values determined by the equations in tables D-4 and D-6 for the channel and basic link, respectively. The values in tables D-5 and D-7 are provided for information only.

**Table D-4 Category 5 channel return loss**

Frequency (MHz)	Return Loss (dB)
$1 \leq f < 20$	15
$20 \leq f \leq 100$	$15 - 10\log(f/20)$
NOTE – $f$ is the frequency in MHz	

(D-4)

**Table D-5 Category 5 channel return loss representative values**

Frequency (MHz)	Category 5e (dB)
1.0	15.0
4.0	15.0
8.0	15.0
10.0	15.0
16.0	15.0
20.0	15.0
25.0	14.0
31.25	13.1
62.5	10.1
100.0	8.0

**Table D-6 Category 5 basic link return loss**

Frequency (MHz)	Return Loss (dB)
$1 \leq f < 20$	15
$20 \leq f \leq 100$	$15 - 7 \log (f/20)$
NOTE – $f$ is the frequency in MHz	

(D-5)

**Table D-7 Category 5 basic link return loss representative values**

Frequency (MHz)	Category 5e (dB)
1.0	15.0
4.0	15.0
8.0	15.0
10.0	15.0
16.0	15.0
20.0	15.0
25.0	14.3
31.25	13.6
62.5	11.5
100.0	10.1

**D.4.6 Channel and basic link pair-to-pair ELFEXT**

The worst pair-to-pair channel or basic link ELFEXT should meet the values determined using equation (D-6) for all frequencies  $f$  from 1 to 100 MHz when measured in accordance with the FEXT loss measurement procedure in ASTM 4566. The values in table D-8 are provided for information only.

$$ELFEXT_{channel,link} \geq 17 - 20 \log ( f / 100 ) \text{ dB} \tag{D-6}$$

**Table D-8 Category 5 channel and basic link ELFEXT, worst pair-to-pair**

Frequency (MHz)	ELFEXT,channel or basic link, worst pair (dB)
1.0	57.0
4.0	45.0
8.0	38.9
10.0	37.0
16.0	32.9
20.0	31.0
25.0	29.0
31.25	27.1
62.5	21.1
100.0	17.0



#### D.4.7 Channel and basic link PSELFEXT

In a four-pair full duplex transmission scheme, three pairs can be disturbing pairs. In this case, FEXT loss from three near-end transmitters will be present at each far-end receiver. For field test purposes, the pair-to-pair ELFEXT can be summed on a power basis providing a single test limit. The PSELFEXT limit of 14.4 dB at 100 MHz is based on three disturbers, and calculated using equation (D-7). For all frequencies ( $f$ ) from 1 MHz to 100 MHz PSELFEXT should meet the values determined using equation (D-8). The values in table D-9 are provided for information only.

$$PSELFEXT = -10 \log(10^{-X1/10} + 10^{-X2/10} + 10^{-X3/10}) \text{ dB} \quad (\text{D-7})$$

$$PSELFEXT_{channel,link} \geq 14.4 - 20 \log(f / 100) \text{ dB} \quad (\text{D-8})$$

**Table D-9 Category 5 channel and basic link PSELFEXT**

Frequency (MHz)	PSELFEXT, channel or basic link (dB)
1.0	54.4
4.0	42.4
8.0	36.3
10.0	34.4
16.0	30.3
20.0	28.4
25.0	26.4
31.25	24.5
62.5	18.5
100.0	14.4

#### D.4.8 Propagation delay

Propagation delay should be measured in accordance with annex E of ANSI/TIA/EIA-568-B.2 and meet the requirements of subclause 11.2.4.10.

#### D.4.9 Delay skew

Delay skew should be measured in accordance with annex E of ANSI/TIA/EIA-568-B.2 and meet the requirements of subclause 11.2.4.11.

#### D.4.10 Cabling (field) measurement procedures

Category 5 channel testing should be conducted using the procedures specified for category 5e channel testing in subclause 11.2. Category 5 basic link testing should be conducted using the procedures specified for category 5e permanent link testing in subclause 11.2 with the addition of the use of test equipment cords as described in subclauses D.4.10.1 and as shown in figure D-1.

##### D.4.10.1 Test equipment cords and connectors

Test equipment cords should satisfy the category 5e modular patch cord transmission requirements specified in ANSI/TIA/EIA-568-B.2, clause 7.

The connecting hardware on the field test instrument should be periodically inspected for wear. Field test instrument manufacturers should make connecting hardware life-cycle information available along with a simple inspection procedure for the connecting hardware on the field test instrument.

#### **D.4.11 Field failure mitigation procedures**

This section provides procedures in the event that an existing category 5 installation fails either the return loss or ELFEXT.

The corrective actions outlined were derived to accommodate a four-connector topology. In the majority of initially non-compliant cases, fewer than all corrective actions will be required. Select the option(s) that is most appropriate for your situation. It is recommended to re-test for compliance after each option is implemented.

- Option 1: Replace the patch cord with a category 5e patch cord to correct for return loss failures.
- Option 2: Reconfigure the cross-connect as an interconnect.
- Option 3: Replace the transition point or consolidation point connector with a category 5e transition point or consolidation point connector.
- Option 4: Replace the work area outlet connector with a category 5e work area outlet connector.
- Option 5: Replace the interconnect with a category 5e interconnect.

## **ANNEX E (INFORMATIVE) OPTICAL FIBER APPLICATIONS SUPPORT INFORMATION**

This annex is informative only and not part of this Standard.

### **E.1 General**

This annex provides information regarding applications support for many of the available optical fiber LAN applications across the optical fiber media types recognized in this Standard. This compilation allows the user to easily access enough basic information to make informed decisions about optical media choices and system design. With a predetermined knowledge of the required distances, an idea of the applications support required, and the cabling system design, the user can determine the media most appropriate for their needs. This information is not intended to constitute a design guideline.

Two primary factors must be considered in fiber selection and system design – maximum supportable distance and maximum channel attenuation.

The first factor is maximum distance supported based on bandwidth, transmitter and receiver specifications, propagation delay, jitter and numerous other factors. This maximum supportable distance is established by the application standards. Table E-1 lists the maximum supportable distance based on the minimum performance requirements of 62.5/125  $\mu\text{m}$ , 50/125  $\mu\text{m}$ , and singlemode fiber established by this Standard and ANSI/TIA/EIA-568-B.3.

The second factor is maximum channel attenuation. The maximum channel attenuation is established by the difference between the minimum transmitter output power coupled into the fiber and the receiver sensitivity, less any power penalties established. The channel attenuation can be affected by the system design (i.e., number of connections, splices, the length, the wavelength of operation and loss values of components). Table E-1 provides the maximum channel attenuation for each application based on fiber type and wavelength. Equations in subclause E.2 allow users to determine if the system design will remain within the maximum channel attenuation.

### **E.2 Supportable distances and channel attenuation**

Table E-1 lists maximum supportable distances and maximum channel attenuation for optical applications by fiber type. Applications are identified using both industry standard and common names. Data rates listed may differ from actual baud rates due to encoding techniques. The maximum supportable distances and maximum channel attenuation listed apply to the specific assumptions and constraints provided in the notes. Different assumptions or constraints may change the maximum supportable distance and maximum channel attenuation.

**Table E-1**  
**Supportable distances and channel attenuation for optical fiber applications by fiber type**

Application	Wave Length (nm)	Maximum Supportable Distance <sup>2</sup> (m)			Maximum Channel Attenuation <sup>2</sup> (dB)		
		62.5/125 mm	50/125 mm	Single-Mode <sup>7</sup>	62.5/125 mm	50/125 mm <sup>1</sup>	Single-Mode <sup>7</sup>
10BASE-FL (Ethernet)	850	2000		NST	12.5	7.8	NST
Token Ring 4/16	850	2000		NST	13.0	8.3	NST
Demand Priority <sup>3</sup> (100VG-AnyLAN)	1300	2000		NST	7.0	2.3	NST
	850	500		-	7.5	2.8	-
100BASE-FX (Fast Ethernet)	1300	2000		NST	11.0	6.3	NST
FDDI (Low Cost)	1300	500		NST	7.0	2.3	NST
FDDI (Original)	1300	2000		40 000	11.0	6.3	10.0 to 32.0
ATM	52	3000		15 000	10.0	5.3	7.0 to 12.0
	155	2000		15 000	10.0	5.3	7.0 to 12.0
	155 <sup>8</sup>	1000		-	7.2	7.2	-
	622	500		15 000	6.0	1.3	7.0 to 12.0
	622 <sup>8</sup>	300		-	4.0	4.0	-
Fibre Channel	266	1500	1500	10 000	6.0	5.5	6.0 to 14.0
	266 <sup>8</sup>	700	2000	-	12.0	12.0	-
	1062 <sup>8</sup>	300 <sup>4</sup>	500	-	4.0	4.0	-
	1062	-	-	10 000	-	-	6.0 to 14.0
1000BASE-SX (Gigabit Ethernet)	850	220 <sup>5</sup>	550 <sup>6</sup>	-	3.2 <sup>9</sup>	3.9 <sup>9</sup>	-
1000BASE-LX (Gigabit Ethernet)	1300	550	550	5000	4.0 <sup>9</sup>	3.5 <sup>9</sup>	4.7 <sup>9</sup>

**Table E-1 (Concluded)**

1. A worst case source coupling loss of 4.7 dB is used when coupling 50/125  $\mu\text{m}$  fiber to an LED source optimized for use with 62.5/125  $\mu\text{m}$  fiber. This coupling loss is based on the theoretical maximum coupling loss. 10BASE-FL specifies 5.7 dB maximum coupling loss into 50/125  $\mu\text{m}$  fiber. Token Ring, FDDI (Low Cost), FDDI and 100BASE-FX specify 5.0 dB maximum coupling loss into 50/125  $\mu\text{m}$  fiber.
2. "NST" (non-standard) entries indicate where this Standard does not specify support for the media, but where equipment is commonly available to convert the native application signals to a form compatible with the non-native media.
3. Application specifies 62.5/125  $\mu\text{m}$  fiber with 200 MHz•km bandwidth at 850 nm.
4. 300 m (984 ft) capability specified in Fibre Channel update, FC-PH-2.
5. For 62.5/125  $\mu\text{m}$  fiber, IEEE specifies 220 m (721 ft) for 160/500 MHz•km modal bandwidth and 275 m (902 ft) for fiber with 200/500 MHz•km modal bandwidth.
6. For 50/125  $\mu\text{m}$  fiber, IEEE specifies 500 m (1640 ft) for 400/400 MHz•km modal bandwidth and 550 m (1804 ft) for 500/500 MHz•km modal bandwidth.
7. Power budget and distance capability depends on classification option of transmitter and receiver. Distance specified is for the highest power budget option.
8. This is a laser-based application. When not so noted, multimode applications are LED-based.
9. Maximum channel attenuation based on channel insertion loss plus unallocated margin from IEEE 802.3z.
10. Distances for specific implementations should be verified with application standards.

For existing systems, the channel attenuation should be measured in accordance with the test procedures in subclause 11.3 of this Standard. For new installations the system design can be verified using the below equations based on the minimum component specifications established by this Standard and ANSI/TIA/EIA-568-B.3.

$$\text{Channel Attenuation} \leq \text{Maximum Channel Attenuation (from table E-1)} \quad (\text{E-1})$$

$$\text{Channel Attenuation} = \text{cable attenuation} + \text{connector insertion loss} + \text{splice insertion loss} \quad (\text{E-2})$$

$$\text{Channel Attenuation} = [\text{Cable atn coefficient (dB/km)} \times \text{length (km)}] + [\# \text{ connector pairs} \times 0.75 \text{ dB}] + [\# \text{ of splices} \times 0.3 \text{ dB}] \quad (\text{E-3})$$

Therefore to determine maximum length for a particular system design the resulting equation is:

$$\text{Max Length (km)} = \frac{(\text{Max Channel Attn} - [\# \text{ connector pairs} \times 0.75 \text{ dB}] + [\# \text{ of splices} \times 0.3 \text{ dB}])}{\text{Cable attenuation coefficient}} \quad (\text{E-4})$$

$$\text{Calculated maximum length} \leq \text{maximum supportable distance (from table E-1)}$$

The maximum cable attenuation coefficients specified by this Standard and ANSI/TIA/EIA-568-B.3 are listed in table E-2.

**Table E-2 Maximum cable attenuation coefficient**

<b>Wavelength (nm)</b>	<b>62.5 mm</b>	<b>50 mm</b>	<b>Singlemode</b>
850	3.5 dB/km		N/A
1300	1.5 dB/km		0.5 dB/km (outside plant cable) 1.0 dB/km (inside plant cable)

## ANNEX F (INFORMATIVE) BIBLIOGRAPHY

This annex is informative only and is not part of this Standard.

This annex contains information on the documents that are related to or have been referenced in this document. Many of the documents are in print and are distributed and maintained by national or international standards organizations. These documents can be obtained through contact with the associated standards body or designated representatives. The applicable electrical code in the United States is the *National Electrical Code*<sup>®</sup>.

- ANSI/TIA/EIA-526-7-1998, *Optical Power Loss Measurements of Installed Singlemode Fiber Cable Plant*
- ANSI/TIA/EIA-526-14-A-1998, *Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant*
- ANSI/EIA/TIA-604-3-1997, FOCIS, *Fiber Optic Connector Intermateability Standard*
- ANSI/IEEE C 62.11, *Metal Oxide Surge Arrestors for AC Power Circuits*
- ANSI X3.166-1990, *ANSI Standard for Token Ring FDDI Physical Layer Medium Dependent (PMD)*
- ASTM B539-90, *Measuring Contact Resistance of Electrical Connections (Static Contacts)*
- EIA-492A000, *Sectional Specification for Class Ia Multimode, Graded-Index Optical Waveguide Fibers*
- TIA/EIA TSB-31-B, FCC 47 CFR 68, *Rationale and Measurement Guidelines*
- Federal Communications Commission (FCC) Washington D.C., *The Code of Federal Regulations, FCC 47 CFR 68*
- Federal Telecommunications Recommendation 1090-1997, *Commercial Building Telecommunications Cabling Standard*, 11 August 1997, by National Communications System (NCS).
- IEEE 802.3-1998 (also known as ANSI/IEEE Std 802.3-1990 or ISO 8802-3: 1990 (E), *Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications*
- IEEE 802.4-1995, *Standard for Local Area Network Token Passing Bus Access Method, Physical Layer Specification*
- IEEE 802.5-1998 (also known as ANSI/IEEE Std 802.5-1992), *Token Ring Access Method and Physical Layer Specifications*
- IEEE 802.7-1989 (R1997), *Recommended Practices for Broadband Local Area Networks*
- NEMA-250-1985, *Enclosures for Electrical Equipment (1000 Volts Maximum)*
- NQ-EIA/IS-43AH, *Cable for LAN Twisted-pair Data Communications-Detail Specification for Type 8, Undercarpet Cable*, September 1988

- Society of Cable Telecommunications Engineers, Inc., Document #IPS-SP-001, *Flexible RF Coaxial Drop Cable Specification*
- UL 444-90, *UL Standard for Safety Communications Cables*

The organizations listed below can be contacted to obtain reference information.

ANSI

American National Standards Institute (ANSI)  
11 W 42 St.  
New York, NY 10032  
USA  
(212) 642-4900  
[www.ansi.org](http://www.ansi.org)

ASTM

American Society for Testing and Materials (ASTM)  
100 Barr Harbor Drive  
West Conshohocken, PA 19428-2959  
USA  
(610) 832-9500  
[www.astm.org](http://www.astm.org)

BICSI

Building Industry Consulting Service International (BICSI)  
8610 Hidden River Parkway  
Tampa, FL 33637-1000  
USA  
(800) 242-7405  
[www.bicsi.org](http://www.bicsi.org)

CSA

Canadian Standards Association International (CSA)  
178 Rexdale Blvd.  
Etobicoke, (Toronto), Ontario  
Canada M9W 1R3  
(416) 747-4000  
[www.csa-international.org](http://www.csa-international.org)

EIA

Electronic Industries Alliance (EIA)  
2500 Wilson Blvd., Suite 400  
Arlington, VA 22201-3836  
USA  
(703) 907-7500  
[www.eia.org](http://www.eia.org)



FCC

Federal Communications Commission (FCC)  
Washington, DC 20554  
USA  
(301) 725-1585  
[www.fcc.org](http://www.fcc.org)

Federal and Military Specifications

National Communications System (NCS)  
Technology and Standards Division  
701 South Court House Road Arlington, VA 22204-2198  
USA  
(703) 607-6200  
[www.ncs.gov](http://www.ncs.gov)

ICEA

Insulated Cable Engineers Association, Inc. (ICEA)  
PO Box 440  
South Yarmouth, MA 02664  
USA  
(508) 394-4424  
[www.icea.net](http://www.icea.net)

IEC

International Electrotechnical Commission (IEC)  
Sales Department  
PO Box 131  
3 rue de Varembe  
1211 Geneva 20  
Switzerland  
+41 22 919 02 11  
[www.iec.ch](http://www.iec.ch)

IEEE

The Institute of Electrical and Electronic Engineers, Inc (IEEE)  
IEEE Service Center  
445 Hoes Ln., PO Box 1331  
Piscataway, NJ 08855-1331  
USA  
(732) 981-0060  
[www.ieee.org](http://www.ieee.org)

IPC

The Institute for Interconnecting and Packaging Electronic Circuits  
2215 Sanders Rd.  
Northbrook, IL 60062-6135  
USA  
(847) 509-9700  
[www.ipc.org](http://www.ipc.org)

ISO

International Organization for Standardization (ISO)  
1, Rue de Varembe  
Case Postale 56  
CH-1211 Geneva 20  
Switzerland  
+41 22 74 901 11  
[www.iso.ch](http://www.iso.ch)

NEMA

National Electrical Manufacturers Association (NEMA)  
1300 N. 17th Street, Suite 1847  
Rosslyn, VA 22209  
USA  
(703) 841-3200  
[www.nema.org](http://www.nema.org)

NFPA

National Fire Protection Association (NFPA)  
Batterymarch Park  
Quincy, MA 02269-9101  
USA  
(617) 770-3000  
[www.nfpa.org](http://www.nfpa.org)

SCTE

Society of Cable Telecommunications Engineers (SCTE)  
140 Philips Rd.  
Exton, PA 19341-1318  
USA  
(800) 542-5040  
[www.scte.org](http://www.scte.org)

Telcordia Technologies (formerly; Bellcore)  
Telcordia Technologies Customer Service  
8 Corporate Place Room 3C-183  
Piscataway, NJ 08854-4157  
USA  
(800) 521-2673  
[www.telcordia.com](http://www.telcordia.com)

TIA

Telecommunications Industry Association (TIA)  
2500 Wilson Blvd., Suite 300  
Arlington, VA 22201-3836  
USA  
(703) 907-7700  
[www.tiaonline.org](http://www.tiaonline.org)

UL

Underwriters Laboratories, Inc. (UL)

333 Pfingsten Road

Northbrook, IL 60062-2096

USA

(847) 272-8800

[www.ul.com](http://www.ul.com)





