

UPCOMING CHANGES IN CABLING STANDARDS

The networking industry changes very rapidly. One contributing factor to the explosive growth of LANs, WANs, and the Internet has been the ANSI/TIA/EIA-568-A cabling standards, in place since 1995. Standards greatly facilitate network interoperability, network design, network device and component manufacture, and network installation. Throughout this curriculum, you will see references to the ANSI/TIA/EIA-568-A standards. Replacement standards, known the ANSI/TIA/EIA-B.1, B.2, and B.3 standards, are scheduled to be completed and released in 2001. But until all of the ANSI/TIA/EIA-568-B standards are released, the A standards remain in effect. Among other improvements, these standards will be in much better alignment with the standards used outside the US – especially the ISO/IEC 11801 updated standards.

The ANSI/TIA/EIA-B.1 standards, not yet released, will deal with General Requirements: Cabling and Field Testing. They are particularly important for network design of copper and fiber systems. The ANSI/TIA/EIA-B.2 standards, also not yet released, will deal with Copper Requirements: Cabling and Connectors. These standards will be very specific. The ANSI/TIA/EIA-B.3 standards, released in April of 2000, deal with Fiber Requirements: Connectors and Cables. In general, these new standards enable the installation of higher bandwidth copper technologies (such as 100BASE-TX and 1000BASE-T) and higher bandwidth optical fiber systems (such as 1000BASE-LX and 1000BASE-SX).

A notable specific change for copper is that Category 5e (“e” for enhanced) is now the minimum specified data cable. Cat 5e differs from Cat 5 in that it is required to pass more complex tests in order to guarantee its reliability for high bandwidth communications. A notable specific change for optical fiber is the recognition of small form-factor (SFF) connectors.

This document provides a detailed summary of the upcoming cabling standards developments. It is a combination of the ANSI/TIA/EIA-568-B.1, B.2, and B.3 standards, consolidated to make it easier to read. Of course, even after this consolidation, it is still highly technical.

The content of this chapter is not required for the CCNA Exam, and it will not be on any CCNA Online Assessments.

It is provided to share with our community a major change, which is about to occur. The document contains many technical terms and concepts, which we will be elaborating upon in future months with more explanations, more graphics, Flash animations, and interactive Flash activities.

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ANSI/TIA/EIA-568-B.1

(Combined with certain elements of B.2)

Recognized horizontal twisted-pair cables

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

1. four-pair 100 Ohm unshielded twisted-pair (UTP) or screened twisted-pair (ScTP) cables, 0.51 mm (24 AWG) to 0.64 mm (22 AWG) in diameter.

NOTE: Performance requirements for cables specified in ANSI/TIA/EIA-568-B.2.

The recognized categories of UTP cabling are:

- Category 5e: This designation applies to 100 Ohm UTP cables and associated connecting hardware whose transmission characteristics are specified up to 100 MHz.
 - Category 3: This designation applies to 100 Ohm UTP cables and associated connecting hardware whose transmission characteristics are specified up to 16 MHz.
 - Categories 1, 2, 4 and 5 cables and connecting hardware are not recognized as part of ANSI/TIA/EIA-568-B.1 and ANSI/TIA/EIA-568-B.2, therefore their transmission characteristics are not specified.
2. two or more cores of optical fiber multimode cable, either 62.5/125 μm or 50/125 μm cables.

NOTE: Performance requirements for cables specified in ANSI/TIA/EIA-568-B.3. See a later section in this document for fiber performance.

Requirements

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 performance and color-code specifications for that cable type given in ANSI/TIA/EIA-568-B.2 and ANSI/TIA/EIA-568-B.3.

NOTE: 1 – Hybrid cables and bundled cables are those cables that are assembled prior to installation, sometimes referred to as loomed, speed-wrap, or whip cable constructions.

NOTE: 2 – There are a number of other application specific horizontal cable types that have been used in telecommunications. Although these cables are not part of the requirements of the ANSI/TIA/EIA-568-B.1, ANSI/TIA/EIA-568-B.2 and ANSI/TIA/EIA-568-B.3 standards, they may be used in addition to the minimum requirements described above.

NOTE: 3 – Hybrid cables consisting of optical fiber cores and copper conductors are sometimes referred to as composite cables.

Choosing types of horizontal cabling

Requirements

A minimum of two telecommunications outlet/connectors for each individual work area.

NOTE: One telecommunications outlet/connector may be associated with voice and the other with data. Consideration should be given to installing additional outlet/connectors based on present and projected needs.

The two telecommunications outlet/connectors shall be configured as:

- 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 shall be supported by a minimum of one of the following horizontal media.

Four-pair 100 Ohm category 5e cable as specified in ANSI/TIA/EIA-568-B.2.

Two-fiber multimode optical fiber cable, either 62.5/125 μm or 50/125 μm as specified in ANSI/TIA/EIA-568-B.3

Horizontal cabling length limitations

Horizontal cabling length limits are based on cable length from the termination of the media at the horizontal cross-connect in the telecommunications room to the telecommunications outlet/connector in the work area.

Requirements

- Maximum horizontal length shall be 90 m (295 ft), independent of media type.
- 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 outlet assembly is used.
- If a multi-user telecommunications outlet assembly (MUTOA) is used, the maximum horizontal distance of twisted-pair media shall be reduced in accordance with the open office cabling formula, $C = (102-H) / 1.2$, $W = C-5$.

Recommendations

- 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.

ScTP cabling grounding and bonding considerations

Grounding and bonding systems are an integral part of the screened twisted-pair (ScTP) telecommunications cabling system. In addition to helping protect personnel and equipment from hazardous voltages, a proper grounding and bonding system may reduce EMI to and from the telecommunications cabling system. Improper grounding and bonding can produce induced voltages and those voltages can disrupt other telecommunications circuits.

Requirements

- Grounding and bonding shall support 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 to the telecommunication grounding busbar (TGB) in the telecommunications room.
- 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 workstation shall not exceed 1.0 V RMS. The cause of any higher voltage should be removed before using the cabling.

NOTE: 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.

Backbone hierarchical star topology

The backbone cabling shall use the hierarchical star topology where each horizontal cross-connect in a telecommunications room is cabled either directly to a main cross-connect or through an intermediate cross-connect to a main cross-connect. This topology offers flexibility to support a variety of applications.

Requirements

- 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.
- Bridged taps shall not be used as part of the backbone cabling

Recommendations

- Backbone cabling cross-connects may be located in telecommunications rooms, equipment rooms, or at entrance facilities.

NOTES: The limitation of two levels of cross-connects is imposed to limit signal degradation for passive systems and to simplify moves, adds and changes. This may not be suitable for facilities that have a large number of buildings or that cover a large geographical area. In these cases, it may be necessary to divide the entire facility into smaller areas and then connect these areas together.

Recognized backbone twisted-pair cables

Since backbone cabling supports a wide range of telecommunications services and site sizes, several transmission media types are recognized for use.

Requirements

Recognized media include:

- a) 100 Ω twisted-pair cable (ANSI/TIA/EIA-568-B.2)
- b) multimode optical fiber cable, either 62.5/125 μm or 50/125 μm (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.

NOTE 1 – Crosstalk between individual, unshielded twisted-pairs may affect the transmission performance of multipair copper cables. Annex B of ANSI/TIA/EIA-568-B.1 provides some shared sheath guidelines for multipair cables.

NOTE 2 – There are a number of other application specific backbone cable types that have been used in telecommunications. Although these cables are not part of the requirements of the ANSI/TIA/EIA-568-B.1, ANSI/TIA/EIA-568-B.2 and ANSI/TIA/EIA-568-B.3 standards, they may be used in addition to the minimum requirements described above.

Choosing types of backbone cabling

Backbone cabling specified in ANSI/TIA/EIA-568-B.1 is applicable to a wide range of user requirements. Various factors need to be considered when these media choices are considered. Considerations include:

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

Intrabuilding and interbuilding length limitations

Maximum supportable length limitations are application and media dependent.

Requirements

- The backbone length limitations include the total backbone channel length, including backbone cable, patch cords or jumpers, and equipment cables.
- 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 column A below.

Recommendations

- To minimize cabling distances, it is often advantageous to locate the main cross-connect near the center of a building or site.
- Cabling installations that exceed the standards distance limits may be divided into areas, each of which can be supported by backbone cabling within the scope of the standards.
- The length of category 3 multipair 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 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.
- The 90 m (295 ft) distance limitation assumes uninterrupted cabling runs between cross-connects that serve equipment (i.e., no intermediate cross-connect).

Media Type	A	B	C
100 Ω cabling	800 m (2624 ft)	300 m (984 ft)	500 m (1640 ft)
62.5 μ m cabling	2000 m (6560 ft)	300 m (984 ft)	1700 m (5575 ft)
50 μ m cabling	2000 m (6560 ft)	300 m (984 ft)	1700 m (5575 ft)
singlemode	3000 m (9840 ft)	300 m (984 ft)	2700 m (8855 ft)

- The maximum length of cross-connect jumpers and patch cords in the main and intermediate cross-connections should not exceed 20 m (66 ft).
- The maximum length of cable used to connect telecommunications equipment directly to main or intermediate cross-connections should not exceed 30 m (98 ft).

Work area telecommunications outlet/connector

100 Ohm balanced twisted-pair telecommunications outlet/connector

Requirements

- Each four-pair cable shall be terminated in an eight-position modular outlet at the work area.
- Telecommunications outlet/connectors for 100 Ohm UTP and ScTP cabling 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 below. The T568B pin/pair assignments may be used if necessary to accommodate certain 8-pin cabling systems.
- These illustrations depict the front view of the telecommunications outlet/connector.

Optical fiber telecommunications outlet connectors

Requirements

- Horizontal optical fiber cabling 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.

Recommendations

- 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 (SFF), may also be considered.

Requirements

Work area cords (all media types)

- The maximum work area cable (cord) length shall not exceed 5 m (16 ft).
- All 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.

Open office cabling

Modular office furniture systems provide the flexibility to layout and design collaborative work groups. Such spaces are frequently rearranged to meet changing requirements. An interconnection in the horizontal cabling allows open office spaces to be reconfigured frequently without disturbing horizontal cable runs. This section of the work area describes two cabling solutions that are suitable for use in the open office environment.

Multi-user telecommunications outlet assembly

Multi-user telecommunications outlet assemblies may be advantageous in open office spaces that are moved or reconfigured frequently. A multi-user telecommunications outlet assembly facilitates the termination of 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.

Requirements

- The work area cables shall be connected directly to work area equipment without the use of any additional intermediate connections.
- Maximum work area cable length requirements shall also be taken into account. (i.e., $C = [102-H] / 1.2$, $W = C-5$, where $W \leq 22$ m [71 ft]).

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

Recommendations

- Work area cables originating from the multi-user telecommunications outlet assembly should be routed through work area pathways (e.g., furniture pathways).
- The multi-user telecommunications outlet assembly should be limited to serving a maximum of twelve work areas.
- Spare capacity should also be considered when sizing the multi-user telecommunications outlet assembly.

Consolidation Point

An interconnection point within the horizontal cabling, using ANSI/TIA/EIA-568-B.2 or ANSI/TIA/EIA-568-B.3 compliant cables and connecting hardware. The consolidation point (CP) differs from the multi-user telecommunications outlet assembly (MUTOA) in that it requires an additional connection for each horizontal cable run. 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.

Requirements

- Installed in accordance with the requirements of clause 10 of ANSI/TIA-EIA-568-B.1 and rated for at least 200 cycles of reconnection.
- 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.
- 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.

Recommendations

- For non-fiber 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.
- 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.

Telecommunications rooms

Telecommunications rooms provide many different functions for the cabling system and are often treated as a distinct sub-system within the hierarchical cabling system.

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.

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.

Requirements

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

Recommendations

- In some cases, the demarcation point and associated protection apparatus may be located in the telecommunications room.
- A telecommunications room should be located on the same floor as the work areas served.

Cross-connections and interconnections

Requirements

- 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.
- All connections between horizontal and backbone cables shall be cross-connections.
- Equipment cables/cords that consolidate several ports on a single connector shall be terminated on dedicated connecting hardware.

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.

Recommendations

- 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 also reduce flexibility.

Equipment rooms

Equipment rooms are considered to be distinct from telecommunications rooms because of the nature or complexity of the equipment they contain. An equipment room provides a controlled environment to house telecommunications equipment, connecting hardware, splice closures, grounding and bonding facilities, and protection apparatus where applicable.

Recommendations

- 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.

Cabling installation requirements

Requirements

- Cable and components shall be visually inspected for proper installation.

Recommendations

- 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.

Twisted-pair cabling (UTP and ScTP)

Minimum horizontal cable bend radius

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

Requirements

- The minimum bend radius, under no-load conditions, for 4-pair UTP cable shall not be less than four times the cable diameter and the minimum bend radius of 4-pair ScTP cable, under no-load conditions, shall be eight times the cable diameter.

Minimum backbone cable bend radius

Requirements

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

Minimum patch cable bend radius

Requirements

- The minimum bend radius, under no load conditions, for 4-pair ScTP patch cable shall be eight times the cable diameter.

NOTE – Minimum bend radius conditions and cables not specified under subclause 10.2.1 (i.e., Category 6) are under further study.

Maximum pulling tension

Requirements

- 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.

Connecting hardware termination

As with all cabling media, 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.

Requirements

- 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.
- 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.

Recommendations

- To maintain the cable geometry, remove the cable sheath only as much as necessary to terminate the cable pairs on the connecting hardware.
- 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.

Patch cords, equipment cords, work area cords, and jumpers

Requirements

- 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.

Recommendations

- 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.

100-Ohm ScTP grounding requirements

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.

Optical fiber cabling

Minimum bend radius and maximum pulling tension

Requirements

- 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).

Connecting hardware termination and polarity

Requirements

- 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.
- 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).

Recommendations

- For other duplex connector styles (i.e., small form factor), 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.
- Optical fiber links shall be installed to ensure that on one end, the 568SC or comparable adapter is installed in the A-B orientation and, on the other end, installed in the B-A orientation.

Cabling transmission performance and test requirements

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.

100-Ohm twisted-pair transmission performance and field test requirements

Channel and permanent link test configurations

This section specifies requirements for field test instruments and procedures for field measurement practices that will yield repeatable measurements of installed 100 Ohm twisted-pair cabling links.

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.

Requirements

- The total length of equipment cords, patch cords or jumpers and work area cords shall not exceed 10 m (33 ft).

NOTE – 1 The connections to the equipment at each end of the channel are not included in the channel definition.

NOTE – 2 The channel definition does not apply to those cases where the horizontal cabling is cross-connected to the backbone cabling.

The permanent link test configuration is to be used by system designers and users of data communications systems to verify the performance of the permanent link. 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.

Requirements

- 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.

Test parameters

The primary field test parameters are:

1. Wire map
2. Length
3. Insertion loss
4. Near-end crosstalk (NEXT)
5. Power sum near-end crosstalk (PSNEXT)
6. Equal-level far-end crosstalk (ELFEXT)
7. Power sum equal-level far-end crosstalk (PSELFEXT)
8. Return loss
9. Propagation delay
10. Delay skew

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

Wire map

Intended to verify pair-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:

1. continuity to the remote end
2. shorts between any two or more conductors
3. reversed pairs

4. split pairs
5. transposed pairs
6. any other miswiring

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.

Requirements

- 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 maximum physical length of the permanent link shall be 90 m (290 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).
- 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.

Recommendations

- The 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.

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 link insertion loss is the sum of:

1. insertion loss of all connecting hardware
2. insertion loss of 10 m (32.8 ft) of patch and equipment cord total to make connections on each end of the channel configuration (there is no patch or equipment cord length allotment for the permanent link).
3. insertion loss of the cable segment, based on the prorated insertion loss relative to the insertion loss of a 100 m (328 ft) cable segment.

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.

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 to ASTM D4566 as a power sum on a selected pair from all other pairs.

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 a receive pair from all the far-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.

Cabling return loss

Return loss is a measure of the reflected energy caused by impedance variations in the cabling system.

Propagation delay

Propagation delay is the time it takes for a signal to propagate from one end to the other.

Delay skew

Delay skew is a measurement of the signaling delay difference from the fastest pair to the slowest.

Optical fiber transmission performance and field testing requirements

This section describes the minimum recommended performance test criteria for an optical fiber cabling system installed in compliance with ANSI/TIA/EIA-568-B.1. 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.

Link segment

An optical fiber link segment is the passive cabling that includes cables, connectors, and splices (if present), between two optical fiber connecting hardware termination points. A typical horizontal link segment is from the telecommunications outlet/connector to the horizontal cross-connect. There are three typical backbone link segments:

1. main cross-connect to intermediate cross-connect,
2. main cross-connect to horizontal cross-connect, and
3. 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 illustrated, 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.

Link segment performance

The performance parameters necessary for performance testing, when installing components compliant with ANSI/TIA/EIA-568-B.1 and ANSI/TIA/EIA-568-B.3 is link attenuation. Bandwidth (multimode) and dispersion (singlemode) are important performance parameters, but because they cannot 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 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.

Link attenuation has been based on the connectivity requirements of ANSI/TIA/EIA-568-B.1 and ANSI/TIA/EIA-568-B.3 and specify 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.

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).

Horizontal link measurement

The horizontal optical fiber cabling link segments need to be tested at only one (1) 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 (2) connector pairs, one (1) pair at the telecommunications outlet/connector and one (1) 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.

Backbone link measurement

The backbone optical fiber cabling link segment shall be tested in 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/TIA/EIA-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 should be used to determine acceptance values at each of the applicable wavelengths.

Centralized optical fiber link measurement

A centralized optical fiber cabling link segment shall be tested in one direction at one wavelength only. 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/TIA/EIA-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 (3) connector pairs, one (1) pair at the telecommunications outlet/connector, one (1) pair at the interconnect center in the telecommunications room, and one (1) 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.

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:

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

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.

Centralized optical fiber cabling

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-connections by the use of pull-through cables, an interconnection, or splice.

The horizontal cross-connection as specified in ANSI/TIA/EIA-568-B.1 and 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.

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.

General guidelines

This specifies the use of either pull-through cables, an interconnection, 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.

Requirements

- 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. Adhering to the 300 m (984 ft) limitation will ensure that the recognized cabling system will support multi-gigabit services using centralized electronics.
- 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 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 1 - Pull-through cables are continuous sheath cables that are pulled through a telecommunications room from the centralized cross-connect to the telecommunications outlet/connector.

- Slack storage shall provide bend radius control so that cable and fiber bend radius limitations are not violated.
- Fiber slack shall be stored in protective enclosures.
- Centralized cabling design shall allow for the addition and removal of horizontal and intrabuilding backbone fibers.

Recommendations

- The addition and removal of horizontal links should be performed at the telecommunications room.
- Slack may be stored as cable orunjacketed fiber (buffered or coated).
- Cable slack may be stored within enclosures or on the walls of the telecommunications room.
- The layout of both rack-mount and wall-mount termination hardware should accommodate modular growth in an orderly manner.

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

Backbone cabling design requirements

- Centralized cabling shall support the labeling requirements of 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 the telecommunications outlet/connector shall be labeled as a blue field.
- The blue field shall move to the TR for each circuit that is converted to a cross-connection in the TR.
- Centralized cabling shall be implemented to ensure the correct fiber polarity as specified in ANSI/TIA/EIA-568-B.1 (i.e., A-B orientation at the telecommunications outlet/connector and B-A orientation at the centralized cross-connect).

Backbone cabling design recommendations

- 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.

ANSI/TIA/EIA-568-B.3

Recognized Optical Fiber Cables

Requirements

- The optical fiber media types that are recognized for use include 62/125 μm or 50/125 μm multimode optical fibers and singlemode optical fibers, or a combination of these media.

- Individual fibers and groups of fibers shall be identifiable in accordance with ANSI/TIA/EIA-598-A.

Recognized Optical Fiber Connectors and Adapters

Various small form factor (SFF) connector designs may be used provided that the connector design satisfies the performance requirements specified within annex A of ANSI/TIA/EIA-568-B.3.

Requirements

- These connector designs shall meet the requirements of the corresponding TIA Fiber Optic Connector Intermateability Standard (FOCIS) document.

Optical Fiber Connector and Adapter Color-coding

The multimode connector or a visible portion of it shall be beige in color. The multimode adapter or outlet shall be identified by the color beige. The singlemode connector or a visible portion of it shall be blue in color. The singlemode adapter or outlet shall be identified by the color blue.

Optical fiber cable transmission performance parameters

Optical fiber cable type	Wavelength (nm)	Maximum attenuation (dB/km)	Minimum information transmission capacity for overfilled launch (MHz km)
50/125 μ m	850 nm	3.5	500
	1300 nm	1.5	500
62.5/125 μ m	850 nm	3.5	160
	1300 nm	1.5	500
Singlemode	1310 nm	1.0	N/A
Inside plant cable	1550 nm	1.0	N/A
Singlemode	1310 nm	0.5	N/A
Outside Plant Cable	1550 nm	0.5	N/A

Optical Fiber Bend Radius Requirements

1. 2- and 4-fiber cables intended for horizontal or centralized cabling shall support a bend radius of 25 mm (1 in) under no-load conditions.
2. 2- and 4-fiber cables intended to be pulled through horizontal pathways during installation shall support a bend radius of 50 mm (2 in) under a pull load of 222 N (50 lbf).

3. All other inside plant cables shall support a bend radius of 10 times the cable outside diameter when not subject to tensile load, and 15 times the cable outside diameter when subject to tensile loading up to the cable's rated limit.
4. Outside plant cables shall support a bend radius of 10 times the cable outside diameter when not subject to tensile load, and 20 times the cable outside diameter when subject to tensile loading up to the cable's rated limit.

Optical Fiber Field Testing Requirements

Multimode Cabling

Requirements

- Field test instruments for multimode fiber cabling shall meet the requirements of ANSI/TIA/EIA-526-14-A.

Singlemode Cabling

Requirements

- Field test instruments for singlemode fiber cabling shall meet the requirements of ANSI/EIA/TIA-526-7.

Optical Fiber Connector Loss (attenuation) Requirements

Requirements

- Optical fiber connector loss (mated-pairs), shall not exceed a maximum optical attenuation of 0.75 dB when measured in accordance with ANSI/EIA/TIA-455-59 (field testing) and ANSI/TIA/EIA-526-14-A (one jumper reference test method).

Optical Fiber Splice Loss (attenuation) Requirements

Requirements

- Optical fiber splices, fusion or mechanical, shall not exceed a maximum optical attenuation of 0.3 dB when measured in accordance with ANSI/EIA/TIA-455-34, Method A (factory testing) or ANSI/EIA/TIA-455-59 (field testing).

Optical Fiber Return Loss Requirements

Requirements

- Optical fiber splices, fusion or mechanical, shall have a minimum return loss of 20 dB for multimode, 26 dB for singlemode, when measured in accordance with ANSI/EIA/TIA-455-107.
- The minimum singlemode return loss for broadband analog video (CATV) applications is 55 dB.