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To: TDMM 13th edition manual owners

From: Clarke W. Hammersley, BICSI Director of Publications

Please be advised that BICSI has recently published technical changes to the current *Telecommunications Distribution Methods Manual* (*TDMM*), 13th edition.

While none of these changes are classified as "life safety" issues, there were many other changes such as metric conversion changes to make the conversions more "industry friendly." Some figures were also slightly modified. The changes to each item on a page are clearly marked with a revision bar to the immediate right or left of the change. The RCDD curriculum has also been updated to reflect these changes, as well as the exam database.

Please print the pages and insert them into your existing manual. Because our manuals' pages are double-sided, please print these as such. This will allow you to do a page-for-page change out in your manual. The changes to each item on a page are clearly marked with a revision bar to the right or left of the change, and the footer of each of these pages notes the month and year of the change.

You will notice that many of the pages you have printed do not have these revision bars and changed footers. The reason for this is the page-for-page change outs (meaning only one side of the double-sided page received a change. We want you to be able to pull out your old double-sided page and replace it with the new double-sided page).

If you have any questions, please e-mail me at chammersley@bicsi.org.

Thank you:

Clarke W. Hammersley

Clarke W. Hammersley

BICSI Director of Publications

Balanced Twisted-Pair Channel Performance

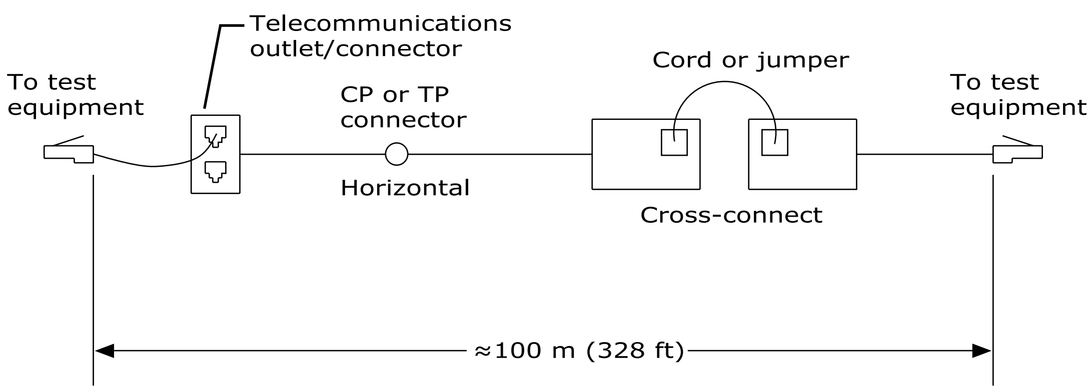
Channel Model

Figure 1.21 shows a channel and the cabling components that determine the channel performance.

The components that may make up the channel consist of a:

- Telecommunications outlet/connector.
- Balanced twisted-pair cable of ≈90 m (295 ft).
- Cross-connect system.
- Equipment and patch cords.
- Consolidation point (CP).
- Horizontal connection point (HCP).
- Transition point (TP).
- Multiuser telecommunications outlet assembly (MUTOA).

Figure 1.21
Example of a channel test configuration



CP = Consolidation point
ft = Foot
m = Meter
TP = Transition point

Performance Parameters

The most important parameters that affect performance are insertion loss, PSNEXT loss, and return loss in the case of bidirectional transmission. Other parameters (e.g., velocity of propagation, delay skew, longitudinal conversion loss, attenuation deviation, PSELFEXT [also called PSACRF]) are also important for certain higher speed applications where more complex encoding schemes and duplex balanced twisted-pair transmissions are implemented.

For 10GBASE-T applications (IEEE 802.3an standard), alien crosstalk parameters, including PSANEXT loss and PSAACRF, are specified.

Insertion Loss Performance Limits

Channel insertion loss is equal to the sum of the attenuation of the various components in the test channel, plus all the mismatch losses at cable and connector interfaces, and the increase in attenuation adjusted for temperature. In the worst case, the channel shown in Figure 1.21 consists of ≈90 m (295 ft) of horizontal cable and up to a total of ≈10 m (33 ft) of equipment and patch cords combined. Generally, patch cords are of flexible stranded construction, thereby presenting higher losses per meter or foot than horizontal cables.

All components must meet the minimum attenuation requirements of the appropriate standard for balanced twisted-pair category or class.

NOTE: In many documents, the terms attenuation and insertion loss are used interchangeably. Strictly speaking, attenuation is a measure of the signal loss under ideal termination conditions where the load and source impedance matches the cable characteristic impedance and all components are exactly matched in impedance.

Near-End Crosstalk (NEXT) Loss Limits

The NEXT loss in the channel is the vector sum of crosstalk induced in the cable, connectors, and patch cords.

NEXT loss is dominated by components in the near zone (less than ≈20 m [66 ft]).

To verify performance, measure NEXT loss from both the TR and the telecommunications outlet/connector. All components must meet the minimum NEXT requirements for the appropriate standard for balanced twisted-pair category or class.

Power Sum Equal Level Far-End Crosstalk (PSELFEXT) Loss Limits

PSELFEXT is a computation of the unwanted signal coupling from multiple transmitters at the near end into a pair measured at the far end. PSELFEXT is calculated in accordance with the power sum algorithm. All components must meet the minimum PSELFEXT requirements for the appropriate standard for balanced twisted-pair category or class.

Return Loss Limits

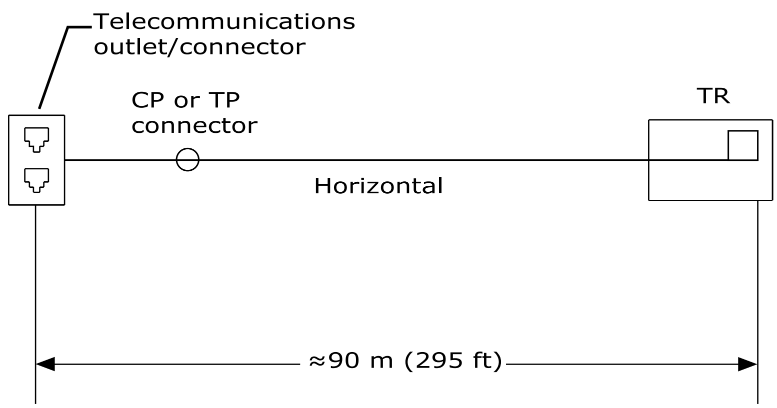
Return loss is a measure of the reflected energy caused by impedance mismatches in the cabling system. All components must meet the minimum return loss requirements for the appropriate standard for balanced twisted-pair category or class.

Balanced Twisted-Pair Permanent Link Performance

Permanent Link Model

Figure 1.22 depicts a permanent link model.

Figure 1.22
Permanent link test configuration



CP = Consolidation point
ft = Foot
m = Meter
TP = Transition point
TR = Telecommunications room

Permanent link consists of up to ≈90 m (295 ft) horizontal cabling, including a connector at each end.

Balanced Twisted-Pair Patch Cords and Cross-Connect Jumpers

Cross-connect jumpers and cables used for patch cords shall meet the same transmission performance requirements as those specified for 100-ohm horizontal cabling with the following exceptions:

- Stranded conductor cable has more attenuation than solid conductor cable.
- A requirement in the category 5e, category 6, category 7, and higher standard is a patch cord return loss test. The patch cord is often a weak link in a cabling system. The patch cord return loss test requires that the patch cord be tested before and after mechanical handling to ensure that the impedance remains stable and within tight limits.

A deviation of greater than ± 5 ohms above a nominal impedance of 100 ohms can result in a failure. It had been observed in practice that many category 5 stranded patch cords tended to exhibit large swings in impedance when flexed or handled. Category 5e and category 6 patch cord designs are optimized to ensure stable return loss performance.

Balanced Twisted-Pair Applications

Design Considerations

As transmission speeds increase and users migrate to higher performance cabling, it is important for the industry to provide guidance on the cabling available for data applications.

The transmission categories of all components used in the same cabling system must be matched to provide a consistently high level of reliability and transmission performance.

The development of new high-speed applications using multiple pairs for parallel transmission has shown a need for additional transmission requirements (e.g., propagation delay, delay skew).

Exercise caution when using cables with mixed insulation since the velocity of propagation can vary with the insulation used, and the skew between pairs may be excessive for some high-speed applications.

To determine the overall suitability of the cabling described for specific applications, the ITS distribution designer should also consult with the:

- Cabling systems suppliers.
- Equipment manufacturers.
- Systems integrators.

Electrostatic Discharge (ESD), continued

Table 2.4 shows ESD susceptibility ranges for a number of devices and equipment. To minimize equipment losses and damages, circuitry has been provided with sophisticated protection schemes.

Table 2.4
Electrostatic discharge susceptibility ranges

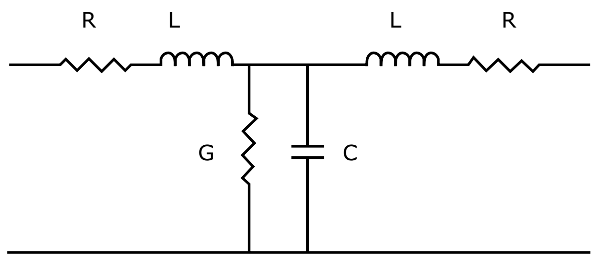
Device	Electrostatic Discharge Susceptibility Voltage (V) Range
Vertical metal oxide semiconductor	30 to 1800
Metal oxide semiconductor field effect transistor	100 to 200
Gallium arsenide field effect transistor	100 to 300
Erasable programmable read-only memory	100
Surface acoustic wave semiconductor devices	140 to 7000
Junction gate field effect transistor	150 to 500
Operational amplifier	190 to 2500
Complementary metal oxide semiconductor	250 to 3000
Schottky diode	300 to 2500
Resistors	300 to 3000
Bipolar junction transistor	380 to 7000
Silicon controlled rectifier	680 to 1000
Schottky transistor-transistor logic	1000 to 2500

Electrostatic Discharge (ESD) Related to Telecommunications Cabling

Although this is not common in practice, telecommunications cabling can be prone to store some energy and then discharge it as ESD. This may happen because of the mutual capacitance of the cable.

A metallic cable or a transmission line can be described in terms of distributed network parameters (e.g., resistance, inductance, capacitance, conductance) per unit length. Generally, the series resistance and inductance per unit length along with the shunt capacitance and conductance per unit length can represent the wireline channel. A model (designated Model T) for an approximate equivalent circuit for a short length is shown in Figure 2.3.

Figure 2.3
Model T for a short wire channel



C = Capacitance
G = Conductance
L = Inductance
R = Resistance

In order to minimize crosstalk, the mutual capacitance of balanced cables decreases as the cable category increases. The result of this (in terms of ESD) is that the potential energy accumulation is lower for higher cable categories (i.e., a category 5e cable is more prone to store energy than a category 6 cable). In other words, the higher the cable category, the lower its ability to store energy.

Table 2.5 shows mutual capacitance value ranges for several telecommunications cable categories (for information only).

Telecommunications Room (TR) Design

Overview

A properly designed TR includes an HC (FD) that provides a floor-serving distribution facility for horizontal cabling.

This cross-connect is capable of providing horizontal cabling connections to floor-serving telecommunications equipment and backbone cables from:

- Other TRs and TEs.
- ERs.
- EFs.

The TR should be provisioned to house telecommunications equipment.

NOTES: Providing separate TRs located in or directly accessible to each tenant's leased space should be considered. For additional information on TR accessibility, see Location in this chapter.

In some cases, it may be necessary to combine the building and floor-serving functions of the ER and TR in one room. Instances where the two may be combined include smaller buildings (i.e., less than ≈502 m^2 [5400 ft^2]) and those with limited space for distribution facilities.

Telecommunications Room (TR) Guidelines

Floor Space Served

There shall be at least one TR or ER per floor.

Multiple rooms are required if the cable length between the HC (FD) and the telecommunications outlet location, including slack, exceeds ≈90 m (295 ft). If the usable floor space to be served exceeds ≈929 m^2 (10,000 ft^2), consider additional TRs.

For TRs that serve areas with an office density of less than one work area per ≈9.3 m^2 (100 ft^2) of usable floor space, a TR may serve larger areas, provided the horizontal cable length requirements are met.

Telecommunications Room (TR) Guidelines, continued

Layout Considerations

When designing the layout of a TR, consider the issues presented in Table 3.4.

Table 3.4
Layout considerations

If…	Then…
A substantial portion of the TR is dedicated to backbone cable distribution	Include space for splicing and ladder racking.
Special telecommunications services are provided	Allow additional space for cross-connect equipment.
More than one tenant is served from the same TR	Provide clear separation and identification of each tenant's equipment and terminations.
An EF is housed at the same location	Include space for cabling protection, grounding (earthing) enclosures, and splice cases.

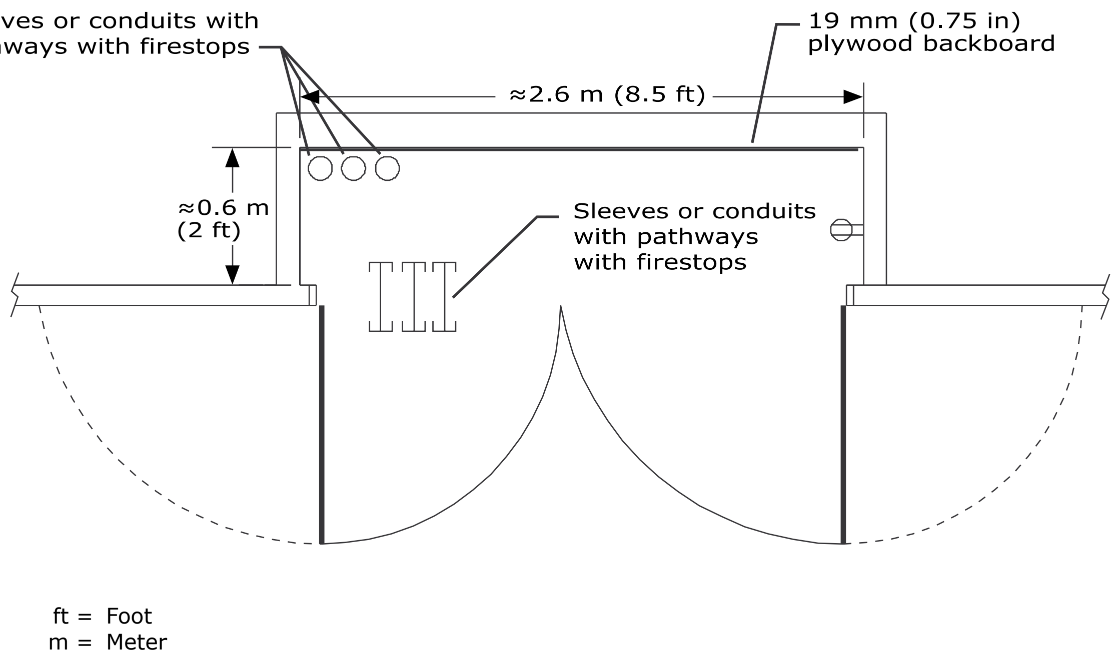
EF = Entrance facility
TR = Telecommunications room

Shallow Room Diagram

A shallow room is defined as an enclosed space for housing cable terminations, cross-connect cabling, and telecommunications equipment.

Figure 3.3 shows a typical layout for a shallow room. The layout may be better suited for splicing than terminations. Sleeve placement shall be considered when using a shallow room so that there is vertical alignment with TRs above and below when used in this manner.

Figure 3.3
Typical shallow room layout



General Requirements for All Telecommunications Enclosures (TEs)

Overview

A TE is simply a case or housing for telecommunications equipment, cable terminations, and cross-connect cabling.

The TE is dedicated to the telecommunications function and related support facilities. The TE may contain access points for wireless services. Although TEs serve much in the same capacity as that of a TR, a minimum of one TR must be located on each floor.

Access

The TEs shall be accessible. Access to TEs should be controlled against unauthorized access (e.g., with a lock and key held by the facility or property manager).

Door

The TE door(s) may be hinged or removable. If the door is hinged, mount the enclosure so that the door swings open a minimum of 90 degrees or otherwise provides unobstructed access to the inside of the enclosure.

The door should remain open until manually closed. Provide and maintain sufficient working space for a technician to gain ready and safe access to the TE.

Electrical Power

A minimum of one dedicated, nonswitched duplex receptacle should be available for equipment power in each TE.

If standby power is available, automatic switchover of power should be provided. Where appropriate, a UPS should be considered.

NOTE: See Chapter 9: Power Distribution for additional information.

Fire Protection

Fire protection of the TEs, if required, shall be provided per applicable code. If sprinklers are required within the area of the TE, the heads should be provided with a protective cover to prevent accidental operation.

A TE should not be installed where subject to leakage from fire suppression sprinklers. Drainage troughs shall be placed under the sprinkler pipes to prevent leakage onto the enclosure.

Choosing Optical Fiber Type

As a general guideline in premises applications for backbone cabling, optical fiber is recommended to support multiple applications with the lengths and data rates as shown in Table 4.2.

Table 4.2
Length and data rates for choosing optical fiber type

Subsystem	Backbone Lengths Up To:	Data Rates Up To:
Campus backbones (OM1 fiber)	≈2000 m (6562 ft)	155 Mb/s
Campus backbones (OM2 fiber)	≈550 m (1804 ft)	1 Gb/s
Building backbones (OM2 fiber)	≈300 m (984 ft)	1 Gb/s
Building backbones (OM3 fiber)	≈300 m (984 ft)/≈100 m (328 ft)	10 Gb/s/100 Gb/s
Campus/building backbones (OM4 fiber)	≈550 m (1804 ft)/≈150 m (492 ft)	10 Gb/s/100 Gb/s
Campus/building backbones (OS1 fiber)	≈10,000 m (32,808 ft)	100 Gb/s
Campus/building backbones (OS2 fiber)	≈10,000 m (32,808 ft)	100 Gb/s

ft = Foot
Gb/s = Gigabit per second
km = Kilometer
m = Meter
Mb/s = Megabit per second
OM1 = Optical multimode 1
OM2 = Optical multimode 2
OM3 = Optical multimode 3
OM4 = Optical multimode 4
OS1 = Optical singlemode 1
OS2 = Optical singlemode 2

Often, a backbone comprised of both multimode and singlemode optical fiber is recommended to satisfy present and future needs in the backbone.

Always follow the original equipment manufacturer (OEM) electronic equipment specifications for optical fiber core size when designing an optical fiber telecommunications system.

Contact the OEM if:

- Specifications vary from the 62.5/125 μm or 50/125 μm multimode standard.
- The optical fiber is used for a unique application.

Backbone Building Pathways (Internal)

Vertically Aligned Telecommunications Rooms (TRs)

Vertically aligned TRs with connecting sleeves or slots are the most common type of backbone pathway. They are desirable because the architect can stack them with other mechanical spaces, and they make distribution of telecommunications cables more efficient because of shorter conduits, bonding, and cabling runs.

NOTE: Ensure that proper firestop is maintained at all times (see Chapter 7: Firestop Systems).

Conduits, Trays, Slots, Sleeves, and Ducts

Conduit Sizing

The metric designators and trade size references listed in this chapter are for identification purposes only and are not intended to represent actual dimensions. Table 4.3 shows the most common sizes of conduits and their designations along with vernacular (where applicable) used in the industry.

Conduit is typically a raceway of circular cross-sectional area whose dimensions are based on the inside diameter (ID) but may also be made of duct or trough used to contain insulated conductors.

Table 4.3
Common conduit sizes with vernacular

Metric Designator	Vernacular	Trade Size	Vernacular
16 mm	–	1/2	1/2 in
21 mm	20	3/4	3/4 in
27 mm	25	1	1 in
35 mm	–	1-1/4	1-1/4 in
41 mm	40	1-1/2	1-1/2 in
53 mm	50	2	2 in
63 mm	–	2-1/2	2-1/2 in
78 mm	75	3	3 in
91 mm	–	3-1/2	3-1/2 in
103 mm	100	4	4 in
129 mm	–	5	5 in
155 mm	–	6	6 in

in = Inch
mm = Millimeter

Application-Specific Components

Some applications or services require specific components (e.g., baluns intended for impedance matching, devices used for splitting 4-pair cabling into two more separate physical lines).

Application-specific devices shall not be used as part of the horizontal cabling system, and, in the case of this application, they shall be kept external to the telecommunications outlet/connector and HC (FD).

Keeping such application-specific components external to the horizontal cabling system will facilitate the use of the cabling for generic network and service requirements.

Transition Points

Undercarpet telecommunications cabling (UTC) is flat, low-profile cabling designed to be installed directly on the surface of a floor and covered with carpet or tiles. In some cases, UTC is implemented as a part of a zone distribution system where cabling runs are restricted to a limited area and serviced by one or more TPs (used to accommodate the transition from round [distribution] to flat [UTC] cable types) within or along the perimeter of the area served.

Although some standards define UTC with TPs as elements of horizontal cabling, this technology is not recommended in telecommunications cabling because of a number of negative aspects related to performance.

UTC may be used as a part of the horizontal distribution system when other distribution systems are not feasible. UTC, under limited circumstances, is deployed in the WA to provide connectivity of WA devices to the horizontal cabling. These UTC systems are composed of two main components—the UTC cabling and the TP where the UTC cabling connects (transitions) to the horizontal cabling. TPs are located in permanent spots such as building columns, permanent walls, and flush floor boxes. UTC connecting hardware and cabling may not be compatible with high-performance balanced twisted-pair cabling.

Bridged Taps

A bridged tap is a method that was widely used in the past to divide one physical communications line into several cabling paths to support multiple analog subscriber devices. A bridge tap has little effect on pure analog transmissions, such as traditional voice services, but can adversely affect digital signals, including potential signal power loss, disruption, and corruption.

Because of the significant risk of decreased performance, bridge taps are not allowed in any balanced twisted-pair cabling system (including inside plant [ISP] and outside plant [OSP]). If a bridge tap is required to support an analog signal in a specific work area, it should be by use of an adapter placed external to the permanent link work area connector (outlet).

Splices

In general, splicing is not permitted within the horizontal cabling system. The only permitted exception is with the use of optical fiber cabling when joining the optical fiber cabling to single-ended cords (i.e., pigtails) to accomplish connection to connecting hardware in the HC (FD) and telecommunications outlet/connector. When used in this manner, there shall be no more than two splices in the individual horizontal cabling channel.

Horizontal Cabling Media

Allowed Media Types

The following types of transmission media are allowed in the horizontal cabling system:

- Category 5e, 6, 6_A, 7, and higher four-pair 100-ohm balanced twisted-pair cables and corresponding connecting hardware
- OM1 (62.5/125-µm) optical fiber multimode cables and corresponding connecting hardware
- OM2 (50/125-µm) optical fiber multimode cables and corresponding connecting hardware
- OM3 (50/125-µm) optical fiber multimode cables and corresponding connecting hardware
- OM4 (50/125-µm) optical fiber multimode cables and corresponding connecting hardware
- OS1 (8-10/125-µm) optical fiber singlemode cables and corresponding connecting hardware
- OS2 (8-10/125-µm) optical fiber singlemode cables and corresponding connecting hardware

Details relating to the horizontal cabling system transmission media and connecting hardware can be found in Chapter 6: ITS Cables and Connecting Hardware.

Distances

Cabling segment lengths are defined based on the physical length of the cable jacket.

Within the permanent link, the maximum cable length shall be no more than ≈90 meters (m [295 feet (ft)]) regardless of the type of transmission media used.

Within the channel, the total length of cabling shall not exceed ≈100 m (328 ft). In addition, the total combined length of flexible cabling (e.g., equipment cords, patch cords) within the channel shall not exceed ≈10 m (33 ft) except when longer work area equipment cords are permitted in conjunction with a MUTOA.

When utilizing balanced twisted-pair cabling, in addition to the requirements above, an individual balanced twisted-pair cord used within the channel but not within the permanent link shall be no longer than:

- ≈5 m (16.5 ft) for 24 American wire gauge (AWG) [0.51 mm (0.020 in)] cords.
- ≈3.96 m (13 ft) for 26 AWG [0.41 mm (0.016 in)] cords.

Telecommunications Outlet/Connector, continued

Optical Fiber Telecommunications Outlet/Connector

There are many optical fiber connector/adapter types that satisfy the mechanical and transmission performance specifications of cabling standards. The ITS distribution designer may consider any of these optical fiber connector/adapters. Three of the most common multimode and singlemode optical fiber connectors used are:

- Subscriber connector (SC)
- Straight terminus (ST)
- Latching connector (LC)

NOTE: For detailed information on optical fiber connectors, refer to Chapter 6: ITS Cables and Connecting Hardware.

Telecommunications Outlet Box Location Considerations

The following guidelines for planning the location of telecommunications outlets in the work area should be considered:

- Each work area shall have a minimum of one balanced twisted-pair telecommunications outlet box. For work areas in which it may be difficult to install future additional telecommunications outlets/connectors (e.g., in private offices), a minimum of two telecommunications outlet boxes should be provided and located for equipment access flexibility (e.g., on opposing walls).
- Work area telecommunications outlet box size requirements vary based on codes, standards, and best practices as follows:
  - The outlet box should be a minimum of ≈100 millimeters (mm [4 inches (in)]) × ≈100 mm (4 in) × ≈57 mm (2.25). This will accommodate one or two 27 mm (1 trade size) conduits.
  - Where a larger conduit is required, the box size should be increased accordingly. A maximum 35 mm (1-1/4 trade size) conduit will require an ≈120 mm (4 11/16 in) × ≈120 mm (4 11/16 in) × 64 mm (2.50 in) outlet box. Specialty boxes may be used in place of the above as appropriate.

Telecommunications Outlet/Connector, continued

Special attention should be given to the diameter of the cable specified. The cable diameter and the number of cables specified will determine the minimum size conduit required:

- Telecommunications outlet boxes may require supports for attaching the box and a suitable faceplate to support the telecommunications outlets/connectors that are housed by the work area telecommunications outlet box.
- The work area telecommunications outlet box should be located near an electrical outlet (e.g., within ≈1 m [3.3 ft]) and installed at the same height.
- Floor-mounted telecommunications outlet boxes and monuments and the work area equipment cords extending from them can present a tripping hazard. The location of these floor-mounted telecommunications outlet boxes should be coordinated with furniture to minimize such hazards and should be removed when not in use.
- Cabling system performance may be sensitive to the arrangement and organization of cable slack located behind the telecommunications outlet/connector. This general rule applies to all forms of media. Sufficient space shall be provided in the telecommunications outlet box or equivalent space so that minimum cable bend radius requirements are not exceeded.

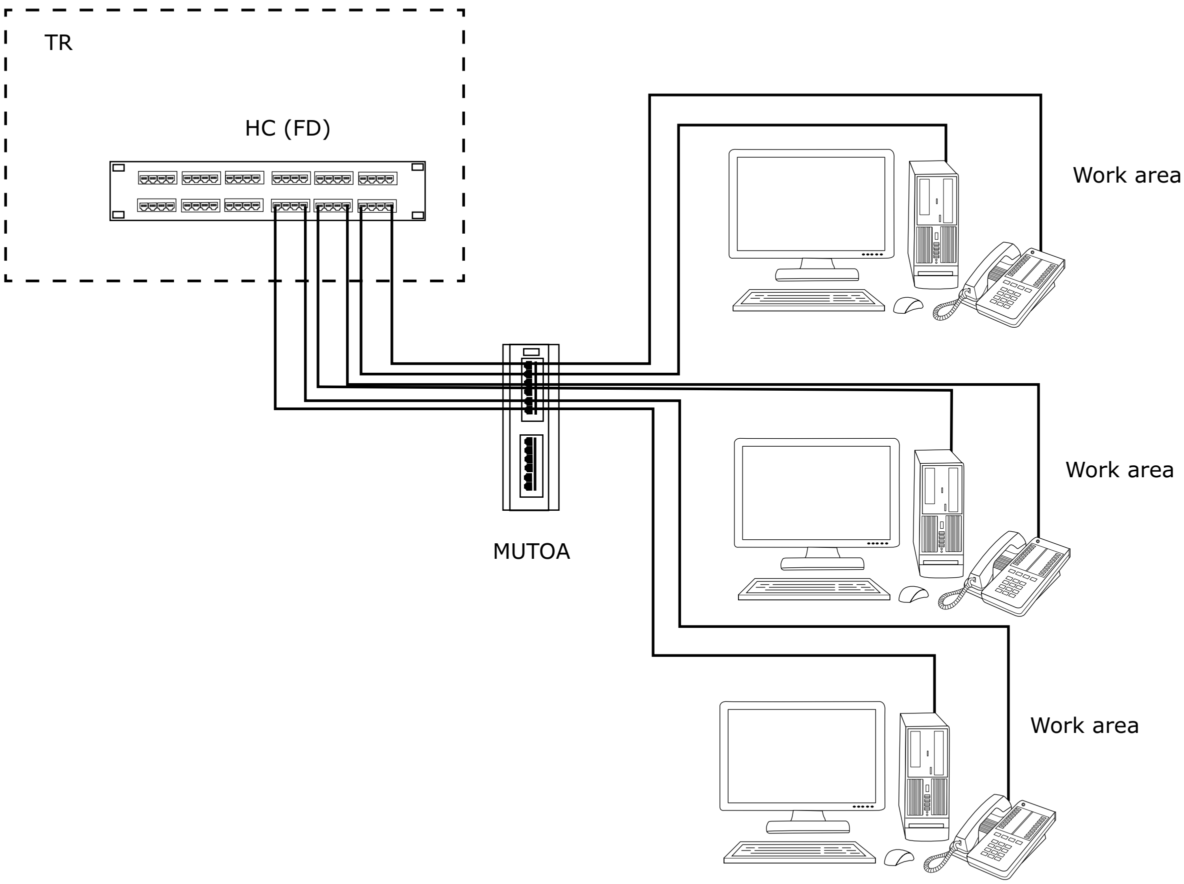
The location, mounting, or strain relief of the telecommunications outlet/connector should allow pathway covers and trim to be removed without disturbing the cabling termination. Care should be exercised to ensure that telecommunications outlets/connectors are mounted in such a way that they do not significantly reduce the required pathway cabling capacity.

Open office furniture openings provide for mounting faceplates containing one or more telecommunications outlets/connectors. Numerous sizes of openings are commonly available. A minimum clearance of ≈30.5 mm (1.2 in) should be provided. If openings are not available, the telecommunications outlet/connector box should be secured to the kick plate with screws that are blunt or filed in the back to ensure they do not damage telecommunications cabling or electrical power wiring.

Multiuser Telecommunications Outlet Assembly (MUTOA), continued

Figure 5.13 is an example of an open office work area design using a MUTOA. Multiple work areas are served by one or more MUTOA.

Figure 5.13
Example of multiuser telecommunications outlet assembly application



HC (FD) = Horizontal cross-connect (floor distributor)
MUTOA = Multiuser telecommunications outlet assembly
TR = Telecommunications room

Multiuser Telecommunications Outlet Assembly (MUTOA), continued

Multiuser Telecommunications Outlet Assembly (MUTOA) Design Considerations

Each open office furniture cluster should be served by at least one MUTOA. A single MUTOA should be limited to serving a maximum of 12 work areas (all part of one furniture cluster), taking into account the maximum work area equipment cord length requirements. The larger the MUTOA capacity, the longer the work area equipment cords are likely to span. Spare capacity should be considered when sizing the MUTOA. The use of high-density patch panels may in some cases be used as a MUTOA.

The use of a MUTOA cabling design option allows work area equipment cords to extend beyond ≈5 m (16.5 ft), depending upon the length of the horizontal cable.

NOTE: The total channel length is reduced as the horizontal cable is shortened because stranded conductor cables contribute more insertion loss (attenuation) than solid conductor cables. Do not use 24 AWG [0.51 mm (0.020 in)] work area equipment cords with lengths that exceed ≈22 m (72 ft).

Maximum lengths in Table 5.1 are based on stranded work area equipment cords exhibiting up to 20 percent higher insertion loss than solid horizontal cable.

NOTE: Screened balanced twisted-pair work area equipment cords with stranded conductors may exhibit attenuation losses up to 50 percent higher than the corresponding solid horizontal cable.

The maximum length of the open office work area equipment cords, based upon insertion loss considerations, shall be determined according to the following formula:

$$C = \left(\frac{102\text{-}H}{1+D}\right)$$

$$W = C\text{-}T$$

$$W \leq 22 \text{ m for 24 AWG [0.51 mm (0.020 in)] cords,}$$

$$W \leq 16 \text{ m for 26 AWG [0.41 mm (0.016 in)] cords}$$

Where:

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

H is the length (m) of the horizontal system cable.

D is an insertion loss derating factor:
20% (0.2) – for 24 AWG [0.51 mm (0.020 in)] cords,
50% (0.5) – for 26 AWG [0.41 mm (0.016 in)] cords.

W is the maximum length (m) of the work area equipment cord.

T is the maximum total length (m) of HC (FD) equipment cords and optional HC (FD) patch cords in the TR:
5 m (16.5 ft) for 24 AWG [0.51 mm (0.020 in)] cords,
4 m (13 ft) for 26 AWG [0.41 mm (0.016 in)] cords.

Multiuser Telecommunications Outlet Assembly (MUTOA), continued

Table 5.1 contains the reference data calculated using the above formulas taking into account the requirements for maximum allowable length of HC (FD) equipment cords and HC (FD) patch cords in the TR.

Maximum length of the balanced twisted-pair horizontal cabling system when using a MUTOA shall not be more than ≈90 m (295 ft) regardless of transmission media type.

The total length of the balanced twisted-pair horizontal channel, including the permanent link, work area equipment cord, HC (FD) patch cords, and HC (FD) equipment cord in the horizontal cross-connect when using a MUTOA shall not be more than ≈100 m (328 ft).

Table 5.1
Maximum allowable cable lengths with the use of multiuser telecommunications outlet assemblies

	24 AWG [0.51 mm (0.020 in)] Patch Cords		26 AWG [0.41 mm (0.016 in)] Patch Cords	
Length of Horizontal System Cable m (≈ft)	**Maximum Length of Work Area Cord m (≈ft)**	**Maximum Combined Length of Work Area Cords, Patch Cords, and Equipment Cords m (≈ft)**	**Maximum Length of Work Area Cord m (≈ft)**	**Maximum Combined Length of Work Area Cords, Patch Cords, and Equipment Cords m (≈ft)**
90 (295)	5 (16.5)	10 (33)	4 (13)	8 (26)
85 (279)	9 (30)	14 (46)	7 (23)	11 (36)
80 (262)	13 (43)	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)

NOTE: No reduction of optical fiber cabling equipment cords in the work area or equipment cords and patch cords at the horizontal cross-connect is required.

Multiuser Telecommunications Outlet Assembly (MUTOA), continued

MUTOAs shall be administered by the rules specified for connecting hardware found in Chapter 10: Telecommunications Administration.

Since work area equipment cords connecting the MUTOA to the work area active equipment may be rather long (up to ≈22 m [72 ft]), they should be labeled on both ends with a unique cable identifier. The end of the work area equipment cord at the MUTOA should be labeled with the work area identifier it serves, and the end at the work area active equipment should be labeled with the MUTOA and its position identifier.

Locating Multiuser Telecommunications Outlet Assemblies (MUTOAs)

MUTOAs shall be located in fully accessible, permanent locations (e.g., building columns, permanent walls). Do not install MUTOAs in ceiling spaces, under access flooring, or in any obstructed areas. MUTOAs shall not be installed in furniture unless that furniture is permanently secured to the building structure.

For balanced twisted-pair cabling, MUTOAs should be located at least ≈15 m (50 ft) from the HC (FD) to minimize the effects of multiple connections in close proximity on near-end crosstalk loss and return loss.

When using MUTOAs in areas with WAPs, give special attention to the installation of the cabling to access points directly from the TR/TE, not from the MUTOA located in the area. MUTOAs are only intended to service devices in furniture clusters.

The work area side of the MUTOA should be marked with the maximum allowable work area equipment cord length. See Chapter 10: Telecommunications Administration for additional details about labeling and record keeping.

Consolidation Point (CP)

The consolidation point (CP) is an interconnection point within the horizontal cabling system. Like the MUTOA, a CP may be used for balanced twisted-pair cabling or optical fiber cabling.

The functional difference between the CP and the MUTOA in the open office environment is that the CP introduces an additional connection for each horizontal cabling run.

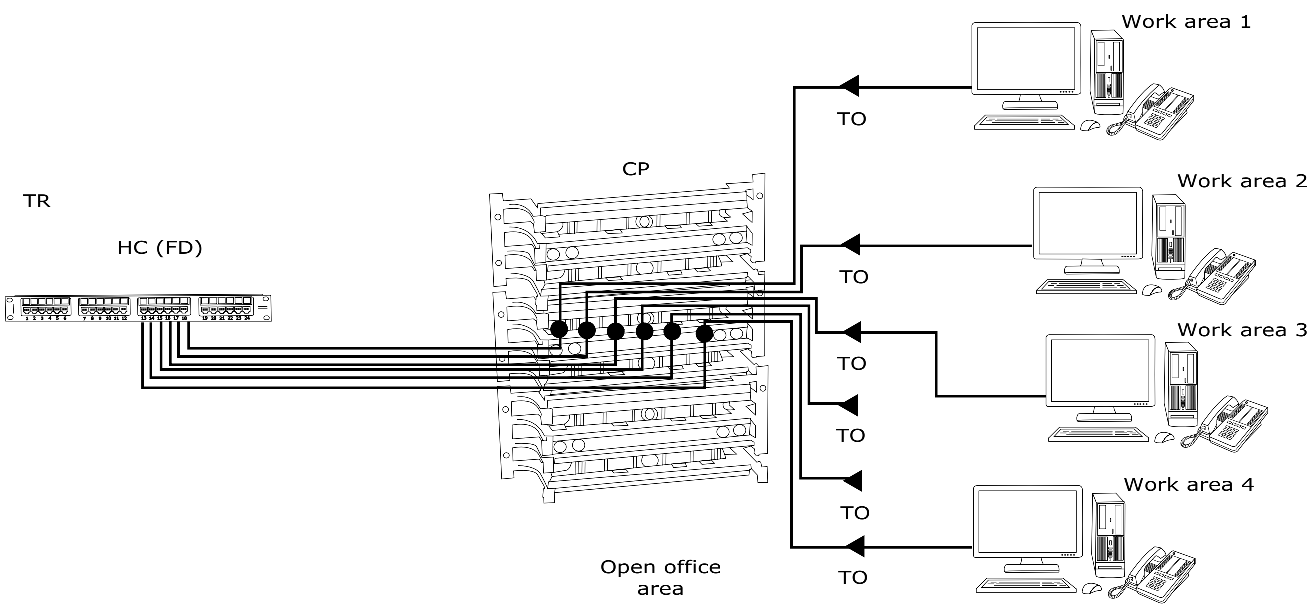
A CP may be useful when reconfiguration is frequent, but not so frequent as to require the flexibility of the MUTOA.

The CP provides a convenient method for rearrangement of horizontal cabling that may be employed in furniture system layouts. CPs can also be used to serve private office arrangements, especially when zone cabling is employed. See Figure 5.14 for an example of CPs being used in a combined furniture system and private office work area environment.

A CP allows standard horizontal cables to be extended into work area pathways and terminated on telecommunications outlets/connectors that are dedicated to each individual user.

However, the use of a CP does not extend the length of horizontal cabling farther than ≈90 m (295 ft) from the cable termination at the HC (FD) to the cabling termination at the telecommunications outlet/connector or MUTOA.

Figure 5.14
Consolidation points used in a combined furniture system and private office work area environment



CP = Consolidation point
HC (FD) = Horizontal cross-connect (floor distributor)
TO = Telecommunications outlet/connector
TR = Telecommunications room

Consolidation Point (CP), continued

Consolidation Point (CP) Design Considerations

CP implementation is a variation of horizontal cabling. Therefore, a good first step in the design of the CP is to review the rules and guidelines provided in this chapter before proceeding further. Some cabling systems manufacturers and certain categories of cabling may not recommend the use of CPs. Always check with the cabling system manufacturer to validate all product warranties and design or installation recommendations.

When used, each open office furniture cluster should be served by at least one CP. It is recommended that the CP should be limited to serving a maximum of 12 work areas. Spare capacity should be considered when sizing the CP.

The CP can be located in the following spaces, if permitted by codes, standards, and regulations:

- Suspended ceilings
- Access floors
- Modular office furniture
- Work area

Some additional considerations and guidelines that apply specifically to the CP include:

- CPs shall not be used for direct connection to active equipment. Cross-connections shall not be used at a CP. No more than one CP shall be used within the same horizontal system cabling run.
- For balanced twisted-pair cabling, the CP should be located at least ≈15 m (50 ft) from the HC (FD).
- CPs shall be located in fully accessible and permanent locations. CPs shall not be located in an obstructed area.
- The CP shall be sized and cabled so that it meets the telecommunications requirements of the zone it serves. If the floor space requirements change for an existing CP, then the CP should be reconfigured to accommodate the new requirements.
- Regardless of where they are installed, CPs shall be administered in the same manner as telecommunications cabling (cable and connecting hardware), pathways, and spaces as described in applicable cabling administration standards.

NOTE: Refer to Chapter 10: Telecommunications Administration for additional information.

Centralized Optical Fiber Cabling

Overview

The HC (FD), deployed throughout a building and located on each floor of a building, offers maximum flexibility to the user, especially in the deployment of distributed electronics or in multitenant buildings. In spite of the advantages of distributed cross-connections, many users of high-performance optical fiber cabling are implementing data networks with centralized electronics.

A centralized optical fiber cabling topology is based on the principles of a centralized optical fiber network when using recognized optical fiber cabling in the horizontal system to support centralized electronics and fiber-to-the-desk technology.

Centralized cabling provides connections from the work areas to the centralized cross-connect by allowing the use of any of the following methods:

- Pull-through cabling from the centralized cross-connection
- Interconnection cabling in a floor-serving telecommunications space
- Spliced cabling in a floor-serving telecommunications space

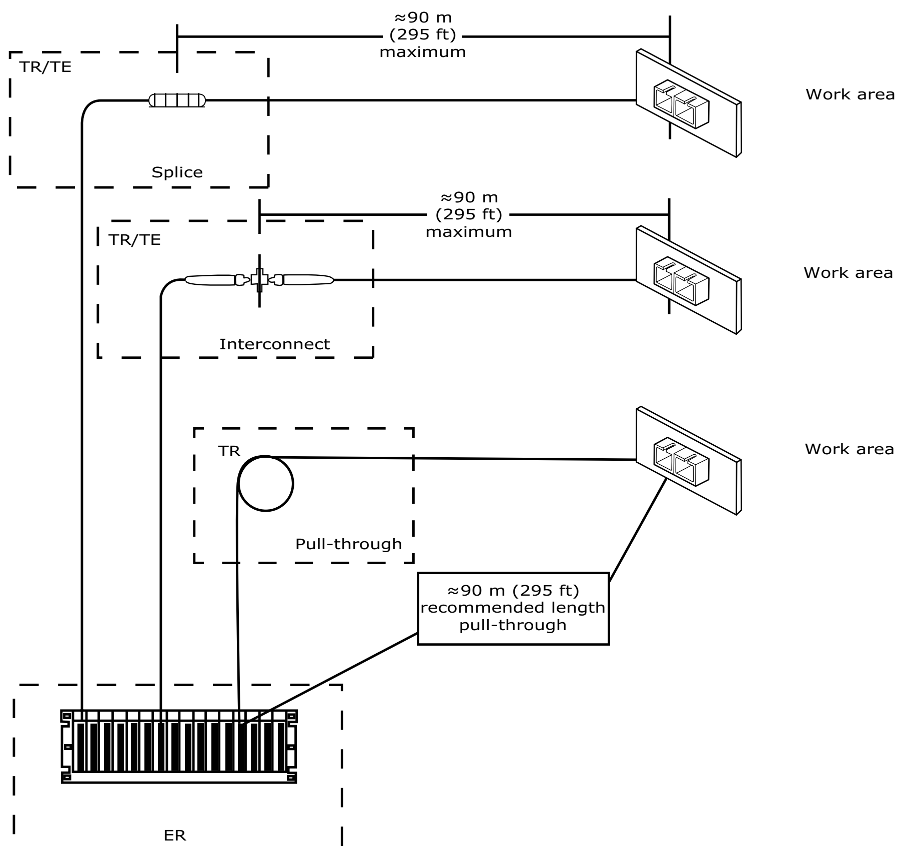
Overview, continued

Figure 5.19 illustrates the centralized optical fiber network and the methods used for its implementation.

Careful planning and implementation of centralized optical fiber cabling will ensure adequate flexibility and manageability with the centralized optical fiber network. It is recommended to consult with equipment manufacturers and system integrators to determine if these requirements are suitable for specific networking applications.

The guidelines and requirements for centralized optical fiber cabling networks are intended for those users who need an alternative to locating the cross-connection in the floor-serving TRs while ensuring adequate flexibility and manageability of optical fiber links, including the ability to migrate to a cross-connection located in the floor-serving TR.

Figure 5.19
Centralized optical fiber cabling



ER = Equipment room
ft = Foot
m = Meter
TE = Telecommunications enclosure
TR = Telecommunications room

Centralized Optical Fiber Cabling Design

Centralized optical fiber cabling designs may utilize any of the recognized types of optical fiber cable and connectivity.

Centralized cabling shall be designed so as to allow for migration (in part or in total) of the pull-through, interconnect, or splice implementation to a cross-connection implementation. Sufficient space should be provided in the TR to allow for the addition of patch panels required for the migration of the pull-through, interconnect, or splice to a cross-connection.

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

The intrabuilding backbone system design should allow for sufficient spare capacity to service additional telecommunications outlets/connectors from the centralized cross-connect without the need to pull additional intrabuilding backbone system cables. The intrabuilding backbone system fiber count should be sized to provide present and future applications to the maximum work area density within the area served by the TR. Two fibers are normally required for each application delivered to a work area.

Choosing between the pull through cabling method or backbone cabling methods (e.g., interconnection, splice) may be based on the size of the installation:

- Pull-through installations are typically used for small, one- or two-story buildings with a limited number of users.
- Backbone to horizontal designs are used in larger buildings where permanently routed backbone cables would minimize disruption to firestop assemblies when adding new users to the system.

Centralized Optical Fiber Cabling Distances

The centralized optical fiber cabling installation is limited to optical fiber cabling within a building and may not be deployed between buildings or across a campus. When centralized multimode optical fiber cabling is used, the user needs to be aware of application specific distance limitations. For this reason, the maximum allowable length of centralized optical fiber cabling using the interconnection or splice methods connecting the centralized active equipment to the work area equipment, including equipment cords at both ends, shall be limited by the specifications of anticipated telecommunications applications.

Pull-Through Method

While there are no specific limitations of cable length in the pull-through method, specific applications or multimode cabling properties may limit the overall length. It is recommended that optical fiber cabling lengths do not exceed the maximum length limit for the application or ≈305 m (1000 ft), whichever is smaller.

Interconnection and Splice Methods

The maximum allowable length of centralized optical fiber cabling utilizing the interconnection and splice methods may be limited by the type of optical fiber cabling selected (e.g., multimode, singlemode) and the distance limitations of the optical fiber equipment deployed.

Additionally, the length limitation of centralized optical fiber cabling between the HC (FD) located in the TR or TE and the work area connecting hardware should not exceed ≈90 m (295 ft). When implementing a centralized optical fiber system with the interconnection or splice methods, the interconnection or splice connecting hardware should be located in the floor-serving TR or TE.

Design Considerations for Telecommunications Space-Based Optical Network Terminal (ONT) Deployments

Backbone Fiber Requirements and Terminations

One backbone optical fiber per OLT PON port shall be used per TR. Since there are usually 32 users per PON port, spare capacity should be built-in for future usage. Also, two optical fiber feeder strands to each splitter may be desired to support the redundancy feature. With the design of optical fiber cable in increments of 12, the tubes and ribbons should not be split or shared among TRs.

Horizontal Copper Requirements

From the ONT located in the telecommunications space (e.g., ER, TR, TE), horizontal cabling shall not exceed ≈90 m (295 ft) to the telecommunications outlet/connector serving the edge device (e.g., phone, computer, printer, camera) in order to support voice, data, and PoE communications.

Rack- and cabinet-based ONTs can support PoE and PoE+ standards for power delivery over the balanced twisted-pair horizontal cabling infrastructure.

Voice over Internet Protocol (VoIP) and Analog Voice Delivery

PON manufacturers provide analog ports for POTS at the ONT. ONTs within the telecommunications spaces can allow for bulk analog phones to support either POTS or voice over Internet protocol (VoIP) services via analog lines. These ONTs provide a session initiated protocol conversion from analog (at the end user handset) to IP (either a VoIP soft-switch/local session controller or Class-5 TDM-based service) over the PON infrastructure.

Radio Frequency (RF) Video Distribution

Depending on the ONT deployed, RF video can be deployed over the same PON infrastructure. The same video head-end equipment is required for PON as for a video coaxial network. However, if the ONT already has an F connector, the services can be overlaid onto the singlemode optical fiber 1550 nm wavelength with a designated virtual LAN with no need for additional cabling.

Desktop-Based Passive Optical Network (PON) Solution Architectures

Telecommunications Spaces Requirements (Special Sizing Considerations)

Depending on the architecture, a rack-, cabinet-, or wall-mounted solution can be designed. It is important to consider additional technologies that may be placed in a TR (e.g., access control, video surveillance, intrusion detection). It is suggested that BICSI best practices for telecommunications spaces square footage space be reduced to a shallow TR that acts as a backbone to horizontal fiber patch point rather than a space of active network electronics. Because of the extended distance reach of a PON (referenced in Table 5.5), the need for multiple TRs per floor can be reduced to a single TR of intermediate fiber patch panels. This reduction in space can provide additional square footage for offices or storage.

Desktop-Based Passive Optical Network (PON) Solution Architectures, continued

Telecommunications Spaces Heating, Ventilation, and Air-Conditioning (HVAC) Considerations

With a PON, the passive elements are usually located in the TRs where the access switches are typically installed. Because the majority of PON designs have no power requirements in the TRs, there is no need to have an HVAC requirement to cool the PON electronics.

Horizontal Pathway Special Design Considerations

Some designs deploy factory preterminated fibers that use single connectors or MPOs. Some fiber manufacturers have developed an ≈3 mm (0.12 in) cable jacket that houses 12 fibers, incorporating a 12 fiber MPO. This design allows for the ability to run large amounts of cable in a small pathway. If a cable tray is still a requirement, the size of the tray can be reduced because of the smaller diameter of the fiber compared with balanced twisted-pair cabling. The cable tray should still be sized for future expansion.

Horizontal Fiber Distribution and Work Area Outlet Considerations

Telecommunications space-based splitters can be implemented in several ways. Some optical fiber manufacturers have developed a one rack unit solution available in different splitter variations (e.g., one 1×32, two 1×16, four 1×8). Other designs can be used with splitter modules that fit into a four rack unit housing, which can hold up to 24 1×32 or 2×32 splitters or other splitter configurations. Some vendors have adapted the fiber to the premises OSP fiber distribution hubs to house up to 18 1×32 splitters.

Zone Cabling-Based Splitters

Zone cabling splitters offer an alternative to traditional telecommunications spaces mounted splitters. Since zone cabling splitters are located closer to the end user, this allows for a lower optical fiber implementation cost. If rack space in the floor serving telecommunications space is limited or running multiple strands of optical fiber cabling to a zone is not permitted, placing the splitters in a ceiling-mounted or access floor-mounted enclosure close to the end user outlet locations may be necessary.

Planning for Future Dual Passive Optical Network (PON) Input Optical Network Terminals (ONTs) and Geographically Diverse Cable Routing

Diverse cable paths can deliver survivability all the way to the device connected to the ONT. There are ways to achieve the same redundancy with the use of dual input splitters at the desired location of survivability, which allow for OLT-based geographic diversity of the splitters and ONTs.

Horizontal Pathways

Overview

The requirements in this section are based on commercially accepted best practices. Horizontal pathways consist of structures that conceal, protect, support, and provide access to horizontal cabling between the telecommunications outlets/connectors used to connect work area equipment at the work area and HC (FD) in the serving ER, TR, or TE.

Pathway implementation involves the pathway for containment of or support of cabling as well as related spaces (e.g., pull boxes, splice boxes) that aid in the installation and change of cabling.

When designing a building, the layout and capacity of the horizontal pathway system shall be thoroughly documented in floor plans and other building specifications. The ITS distribution designer is responsible for ensuring that these systems have built-in flexibility to accommodate tenant movement and expansion. In addition, the ITS distribution designer should design the horizontal pathway system to make the maintenance and relocation of cabling as easy as possible.

The design of the horizontal pathway system should accommodate various types of telecommunications cabling in support of multiple applications (e.g., voice, data, video).

When determining the type and size of the pathway, the ITS distribution designer should:

- Consider the quantity and size of cables that the pathway is intended to support.
- Allow for growth of the area served over the planning cycle.

NOTE: All design and construction for pathway systems shall meet or exceed applicable codes, standards, regulations, and AHJ rulings.

Design Considerations

The ITS distribution designer should carefully select and design the types and layout of the horizontal pathway systems. After a building is constructed, it may be more difficult to gain access to horizontal cabling than to backbone cabling. As a result, it would likely take a great amount of skill, effort, and time to make horizontal cabling changes.

It is important to consider the design's ability to:

- Accommodate cabling changes.
- Minimize occupant disruption when horizontal pathways are accessed.

In addition to providing for current occupant needs, the horizontal pathway system design shall:

- Facilitate the ongoing maintenance of horizontal cabling.
- Accommodate future MACs to the cabling, equipment, and services.

Sizing Considerations

Overview

The size requirements for horizontal pathways depend on the following considerations:

- Usable floor space served by the pathway
- Maximum occupant density (e.g., floor space required per individual work area)
- BAS density
- Cabling density (e.g., quantity of horizontal cables planned per individual work area)
- Cable diameter
- Pathway capacity (e.g., requires that fill factor be taken into account)

Usable Floor Space

The usable floor space is generally considered the building area used by occupants for their normal daily work functions. For planning purposes, this space should include hallways, but not other common areas of the building (e.g., restrooms, utility closets).

Maximum Occupant Density

The standard floor space allocation used in a commercial office environment is commonly defined as one individual work area for every ≈9.3 square meters (m^2 [100 square feet (ft^2)]) of usable floor space.

NOTE: In cases where the work area density will be greater than one work area per ≈9.3 m^2 (100 ft^2) of usable floor space or where more than three telecommunications outlets or connectors will be required for each work area, the pathway capacity shall be increased accordingly.

Building Automation Systems (BAS) Density

The standard floor space coverage area estimated for each BAS is a BAS outlet or device for every ≈23 m^2 (250 ft^2) of total floor area. BAS serve both used and unused floor space; therefore, the entire floor space should be taken into account when sizing horizontal pathways.

NOTE: See Chapter 14: Building Automation Systems for more information about BAS density.

Cabling Density

Pathway capacity for BAS should include one cable for each system or coverage area. If the equipment manufacturer permits multiple coverage areas per cable, then the pathway sizing can be adjusted accordingly.

NOTES: If multiple coverage areas are served by a single cable, then multiple channels within the same cable sheath are permitted. Sheath sharing may also be restricted based on safety considerations, applicable codes, standards, regulations, and AHJ rulings.

General Design Guidelines, continued

Determining Adequate Ceiling Space

To determine how much ceiling space is adequate, the ITS distribution designer should:

- Consider the size and depth of the:
  - Structural beams and girders.
  - Column caps.
  - Mechanical services.
- Allow for a minimum of:
  - ≈75 mm (3 in) of clear vertical space above conduits and cables.
  - ≈300 mm (12 in) of clear vertical space above the tray or raceway for overhead ceiling cable tray or raceway systems.

When designing the layout of horizontal pathways in ceiling spaces, the ITS distribution designer should ensure that other building components (e.g., lighting fixtures, structural supports, air ducts) do not restrict access to cable trays or raceways.

Selection of Ceiling Panels

The selection of the ceiling panel type should be coordinated with Table 5.12.

Table 5.12
Guidelines for recommending ceiling panels

Use a Ceiling Panel That Is...	For a…
Readily removable	Lay-in type panel on either a: • Single support channel or • Double support channel. NOTES: Securely install and brace support channels to prevent both vertical and horizontal movement. Use panels built from stable materials to reduce panel damage from periodic handling.
Not readily removable	Lock-in type panel that requires a conduit system.

General Design Guidelines, continued

Restrictions on Ceiling Cabling

Cabling within ceiling space used as a plenum for environmental air shall comply with applicable codes and regulations.

A zone conduit system may be allowed in an air plenum ceiling if:

- Conduits terminate in junction boxes, and
- Short runs of smaller conduit are extended from the junction boxes to the telecommunications outlets/connectors.

Ceiling Zones Method

In the ceiling zones method of ceiling distribution, the usable floor area should be divided into zones of ≈23 m^2 (250 ft^2) to ≈84 m^2 (1000 ft^2) each.

How a zone is divided depends on the zone's purpose. For CPs, zones should preferably be divided by building columns. The design of BAS zones depends on the number of BAS, coverage areas per cable, and other device-related factors.

NOTE: When CPs and CPs/TPs occupy the same zone box, the ITS distribution designer should carefully consider the usable area for the voice and data usage calculations and the total area for the BAS system calculation.

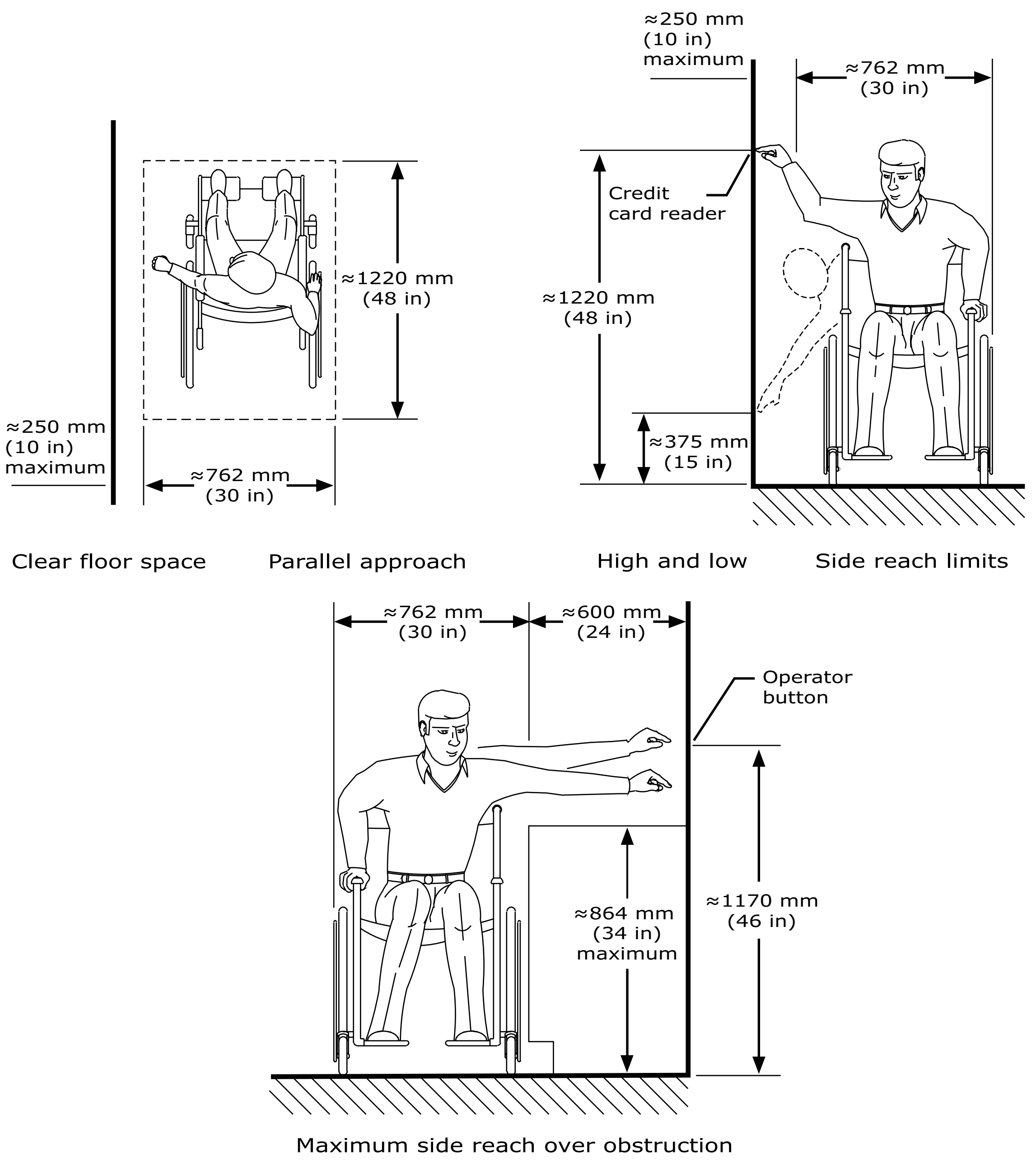
Pathways to each zone may be provided using cable trays within the ceiling area or enclosed conduits or raceways. The raceways, conduits, or cable trays should extend from the telecommunications spaces (e.g., ERs, TRs) to the midpoint of the zone. From that point, the pathway should extend to the top of the utility columns or wall conduit.

NOTE: Appropriate codes, standards, regulations, and AHJ rulings should be consulted for compliance with flame spread and smoke index properties of cables used in cabling pathway systems.

Americans with Disabilities Act (ADA) Height Requirements, continued

Figure 5.34 illustrates the allowed dimensions for side-reach telephones.

Figure 5.34
Side-reach telephones



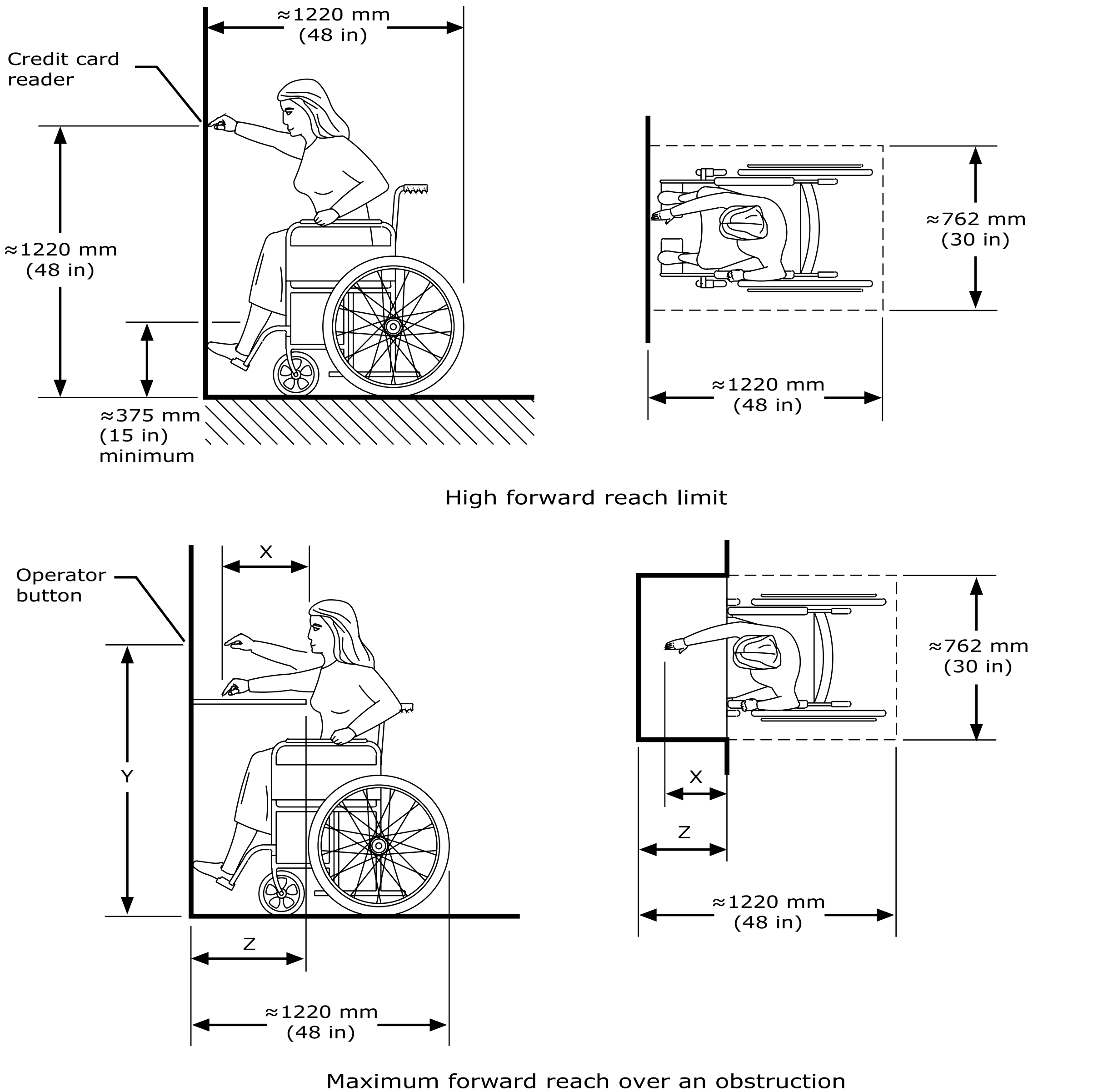
in = Inch
mm = Millimeter

NOTE: The minimum height for all electrical and communications systems receptacles on walls (e.g., outlets, connectors) shall be ≈375 mm (15 in) AFF.

Americans with Disabilities Act (ADA) Height Requirements, continued

Figure 5.35 illustrates the allowed dimensions for forward-reach telephones.

Figure 5.35
Forward-reach telephones



NOTES: X shall be < ≈635 mm (25 in); Z shall be > X. When X < ≈508 mm (20 in), then Y shall be ≈1220 mm (48 in) maximum. When X is ≈508 to 635 mm (20-25 in), then Y shall be ≈1120 mm (44 in) maximum.

BIX-Style Insulation Displacement Contact (IDC) Connector

The BIX-style contacts evolved in the 1970s and became a popular choice for voice and data networks.

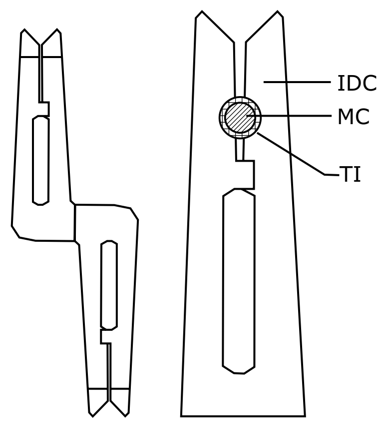
Design

The BIX-style connector consists of an IDC dovetail and a base (see Figure 6.14). Materials used include phosphor bronze alloys plated with tin alloys.

BIX-style connectors can serve as the base for unscreened and screened connecting hardware. Termination of conductors in the BIX-style connector is performed by means of a single-position punch-down tool.

BIX-style connectors are designed for termination of solid metal conductors sized 22 AWG [0.64 mm (0.025 in)] to 26 AWG [0.41 mm (0.016 in)]. None of the standard BIX-style contacts allow termination of more than one conductor in the same contact. The BIX-style connector is capable of at least 200 termination cycles without degrading its reliability.

Figure 6.14
BIX-style insulation displacement contact connector design



IDC = Insulation displacement contact dovetail
MC = Metal conductor
TI = Thermoplastic insulation

BIX-Style Insulation Displacement Contact (IDC) Connector, continued

Characteristics

The characteristics of a BIX-style connector when used in structured cabling applications should be subject to telecommunications cabling component standards (i.e., ANSI/TIA-568-C.2 and ISO/IEC 11801).

Table 6.14 offers an example of a BIX-style connector's transmission performance capabilities.

Table 6.14
Connecting hardware transmission performance categories for BIX-style connectors

ISO/IEC 11801 Ed. 2.0	ANSI/TIA-568-C.2	BIX-Style Connector-Based Connecting Hardware
Class C (1-16 MHz)	Category 3 (1-16 MHz)	Blocks, outlets, panels
Class D (1-100 MHz)	Category 5e (1-100 MHz)	Blocks, outlets, panels
Class E (1-250 MHz)	Category 6 (1-250 MHz)	Blocks, outlets, panels
Class E_A (1-500 MHz)	Category 6A (1-500 MHz)	Outlets, panels
Class F (1-600 MHz)	N/A	N/A
Class F_A (1-1000 MHz)	N/A	N/A

ANSI = American National Standards Institute
IEC = International Electrotechnical Commission
ISO = International Organization for Standardization
MHz = Megahertz
N/A = Not applicable
TIA = Telecommunications Industry Association

NOTE: For additional information on connecting hardware characteristics, refer to Chapter 1: Principles of Transmission.

LSA-Style Insulation Displacement Contact (IDC) Connector, continued

Characteristics

The characteristics of an LSA-style connector when used in structured cabling applications are subject to telecommunications cabling component standards (i.e., ANSI/TIA-568-C.2 and ISO/IEC 11801 Ed. 2.0).

Table 6.15 offers an example of LSA-style connector transmission performance capabilities.

Table 6.15
Connecting hardware transmission performance categories for LSA-style connector-based connecting hardware

ISO/IEC 11801 Ed. 2.0	ANSI/TIA-568-C.2	LSA-Style Connector-Based Connecting Hardware
Class C (1-16 MHz)	Category 3 (1-16 MHz)	Blocks, outlets, panels
Class D (1-100 MHz)	Category 5e (1-100 MHz)	Blocks, outlets, panels
Class E (1-250 MHz)	Category 6 (1-250 MHz)	Blocks, outlets, panels
Class E_A (1-500 MHz)	Category 6A (1-500 MHz)	Outlets, panels
Class F (1-600 MHz)	N/A	N/A
Class F_A (1-1000 MHz)	N/A	N/A

ANSI = American National Standards Institute
IEC = International Electrotechnical Commission
ISO = International Organization for Standardization
MHz = Megahertz
N/A = Not applicable
TIA = Telecommunications Industry Association

NOTE: For additional information on connecting hardware characteristics, refer to Chapter 1: Principles of Transmission.

LSA-Style Insulation Displacement Contact (IDC) Connector, continued

Advantages and Disadvantages

LSA-style connector's advantages are:

- A high-quality, reliable, and durable electrical contact.
- High transmission performance characteristics.
- A short termination time.
- It allows connections to be created in one-pair increments.
- It can be used in a number of different styles of connecting hardware.
- A high density of terminations.
- A wide range of connector configurations—connection, disconnection, and switching.

LSA-style connector disadvantages:

- Comparatively complex and expensive design.
- Conductor termination is performed with a special tool, which is not always available.
- Not widely used by the data communications industry.

Typical Applications

LSA-style connector's typical applications are:

- LSA-style connector blocks.
- Platforms for integrated circuit protection.
- Modular patch panel connectors used for distribution cable conductors termination.
- Modular telecommunications outlets/connectors used for distribution cable conductors termination.

Modular Plug, continued

Modular plugs and connectors are available in various sizes and shapes (keyed and unkeyed). The number of positions (8P) indicates the connector's width, while the number of contacts (8C) installed into the available positions indicates the maximum number of conductors the connector can terminate.

A connector may be sized for eight positions but only have four contacts installed, which saves on manufacturing costs (e.g., connectors are available as 8P2C, 8P4C, and 8P6C). They are all the same physical size but have different numbers of contacts to terminate conductors.

Materials used to build modular plugs are typically flame retardant polycarbonate (body) and phosphor bronze with gold plating over nickel in contact area (contacts).

Characteristics

Modular plug mating connections and transmission performance characteristics, when used in structured cabling applications, are subject to telecommunications cabling component standards.

Table 6.16 provides a brief reference of modular plug transmission performance capabilities.

NOTE: Modular plugs can be used only as part of a cable assembly (equipment cord or patch cord), and the final transmission performance category of the cord should be confirmed by factory testing.

Table 6.16
Modular plug transmission performance categories

ISO/IEC 11801 Ed. 2.0	ANSI/TIA-568-C.2	Modular Plug
Class C (1-16 MHz)	Category 3 (1-16 MHz)	6P4C, 6P6C, 8P4C, 8P8C
Class D (1-100 MHz)	Category 5e (1-100 MHz)	8P8C
Class E (1-250 MHz)	Category 6 (1-250 MHz)	8P8C
Class E_A (1-500 MHz)	Category 6A (1-500 MHz)	8P8C
Class F (1-600 MHz)	N/A	8P10C (RJ style) 8P8C, 4P4C, 2P2C (non-RJ style)
Class F_A (1-1000 MHz)	N/A	8P10C (RJ style) 8P8C, 4P4C, 2P2C (non-RJ style)

ANSI = American National Standards Institute
IEC = International Electrotechnical Commission
ISO = International Organization for Standardization
MHz = Megahertz
N/A = Not applicable
RJ = Registered jack
TIA = Telecommunications Industry Association

NOTE: For additional information on modular cable assembly characteristics, refer to Chapter 1: Principles of Transmission.

Modular Plug, continued

Advantages and Disadvantages

Modular plug's advantages are:

- It is the most widely used plug design in data communications.
- It is the highest-density plug design.
- It is inexpensive and easy to manufacture.
- It is available in a wide variety of configurations.
- It has comparatively high transmission performance characteristics.

A modular plug's disadvantages are:

- It has design-limited transmission performance.
- Mechanical contact results in a limited lifecycle.

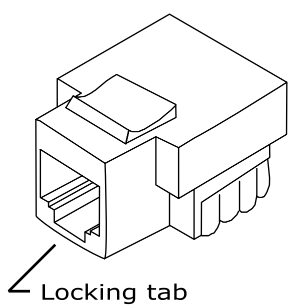
Typical Applications

Modular plug's typical application is equipment cords and patch cords.

Modular Jack

Modular jack is a female telecommunications outlet/connector (socket) that may be keyed or unkeyed and may have 4, 6, or 8 contact positions. Figure 6.18 shows an 8P8C modular jack.

Figure 6.18
8P8C modular jack



Modular Jack, continued

Table 6.17
Modular jack transmission performance categories

ISO/IEC 11801 Ed. 2.0	ANSI/TIA-568-C.2	Modular Jack
Class C (1-16 MHz)	Category 3 (1-16 MHz)	6P4C, 6P6C, 8P4C, 8P8C
Class D (1-100 MHz)	Category 5e (1-100 MHz)	8P8C
Class E (1-250 MHz)	Category 6 (1-250 MHz)	8P8C
Class E_A (1-500 MHz)	Category 6A (1-500 MHz)	8P8C
Class F (1-600 MHz)	N/A	8P10C (RJ style) 8P8C, 4P4C, 2P2C (non-RJ style)
Class F_A (1-1000 MHz)	N/A	8P10C (RJ style) 8P8C, 4P4C, 2P2C (non-RJ style)

ANSI = American National Standards Institute
IEC = International Electrotechnical Commission
ISO = International Organization for Standardization
MHz = Megahertz
N/A = Not applicable
RJ = Registered jack
TIA = Telecommunications Industry Association

NOTE: Additional information on connecting hardware characteristics can be found in Chapter 1: Principles of Transmission.

Advantages and Disadvantages

Modular jack's advantages are:

- It is the most widely used jack design in data communications.
- It has the highest-density jack design.
- It is inexpensive and easy to manufacture.
- It has a wide variety of configurations.
- It has comparatively high transmission performance characteristics.

Modular jack's disadvantages are:

- It has design-limited transmission performance.
- Mechanical contact results in a limited lifecycle.

Typical Applications

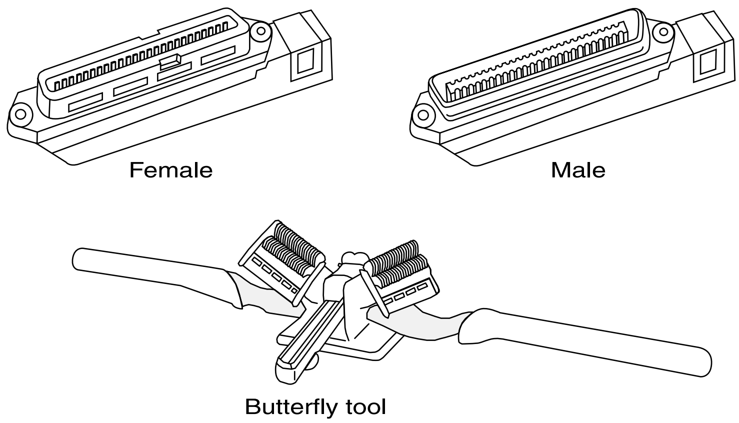
Modular jack's typical applications are:

- Work area telecommunications outlet/connectors.
- Patch panel connectors.
- Prewired connecting blocks and panels.
- Active equipment input and output connectors (ports).

50-Position Miniature Ribbon Connector

The 50-position miniature ribbon connectors have been used in the telecommunications industry as the key system telephone connector (USOC RJ21) for decades. Named after the ribbon-like shape of its contacts, the 50-position miniature ribbon connector provides one of the most reliable and high-density connection interfaces (see Figure 6.21).

Figure 6.21
50-position miniature ribbon connector



The 50-position miniature ribbon connectors are available in both male and female versions and a PCB-mount and cable assembly versions. Connectors used in cable assemblies (e.g., equipment cords, patch cords) require a special tool, called a butterfly tool, for termination.

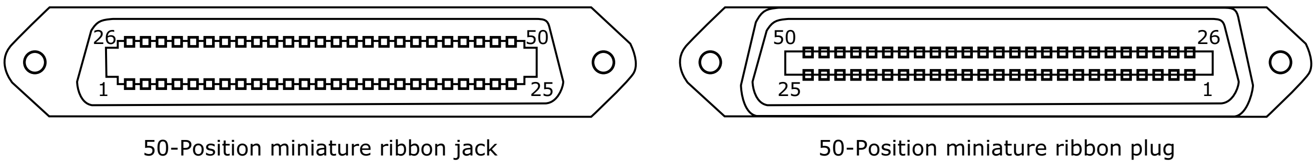
Design

The 50-position miniature ribbon connectors, depending on their usage (e.g., part of active equipment, passive connecting hardware, or equipment cords and patch cords), have different designs and mounting options. Generic design of the contact interface area, which is common for all 50-position miniature ribbon connectors, is shown in Figure 6.22. Typical mounting options and design details may include but are not limited by:

- Active equipment:
  - PCB-mounted soldered or press-fit connectors
  - Plastic or metal-shell interface parts (usually zinc/chromate coated)
  - Bail latches, screws, or panel clips
- Passive connecting hardware:
  - PCB-mounted soldered or press-fit connectors
  - Plastic or metal-shell interface parts (usually zinc/chromate coated)
  - Bail latches, screws, or panel clips
- Equipment cords and patch cords:
  - Solid or stranded IDC contacts
  - Plastic or metal-shell interface parts (usually zinc/chromate coated)
  - Bail latches, screws, or hook-and-loop ties

50-Position Miniature Ribbon Connector, continued

Figure 6.22
50-position miniature ribbon connector design



The 50-position miniature ribbon connectors are manufactured as stand-alone connectors for mounting on prewired patch panels or active equipment PCBs and as part (i.e., plug) of a wide variety of cable assemblies. Connectors used in cable assemblies can provide cable exits at 90, 180, and 270 degrees to the mating plane.

The 50-position miniature ribbon connectors designed as part of equipment cords and patch cords provide termination of 22 AWG [0.64 mm (0.025 in)] to 26 AWG [0.41 mm (0.016 in)] solid or 24 AWG [0.51 mm (0.020 in)] to 28 AWG [0.32 mm (0.013 in)] stranded conductors.

Materials used to build 50-position miniature ribbon connectors are typically steel, fire-retardant high-impact thermoplastic (body) and copper alloys with a gold plating over nickel in contact area (contacts).

50-Position Miniature Ribbon Connector, continued

Characteristics

The 50-position miniature ribbon connectors are not standardized by structured cabling standards, but they are still widely used as adapters for connection of certain styles of active equipment to telecommunications cabling. A 50-position miniature ribbon connector's mating connections and transmission performance characteristics are subject to telecommunications component standards.

Because of their frequent use, manufacturers adapted 50-position miniature ribbon connectors for high-speed data applications. As a result, 50-position miniature ribbon connectors with transmission performance categories 3, 5, and 5e appeared. Table 6.18 offers a brief reference of 50-position miniature ribbon connector transmission performance capabilities.

Table 6.18
50-position miniature ribbon connector transmission performance categories

ISO/IEC 11801 Ed. 2.0	ANSI/TIA-568-C.2	50-Position Miniature Connecting Hardware
Class C (1-16 MHz)	Category 3 (1-16 MHz)	Cords, connecting hardware, CPE
Class D (1-100 MHz)	Category 5 (1-100 MHz)	Cords, connecting hardware, CPE
Class D (1-100 MHz)	Category 5e (1-100 MHz)	Cords, connecting hardware, CPE
Class E (1-250 MHz)	Category 6 (1-250 MHz)	N/A
Class E_A (1-500 MHz)	Category 6A (1-500 MHz)	N/A
Class F (1-600 MHz)	N/A	N/A
Class F_A (1-1000 MHz)	N/A	N/A

ANSI = American National Standards Institute
CPE = Customer provided equipment
IEC = International Electrotechnical Commission
ISO = International Organization for Standardization
MHz = Megahertz
N/A = Not applicable
TIA = Telecommunications Industry Association

Balanced Twisted-Pair Splices, continued

Design

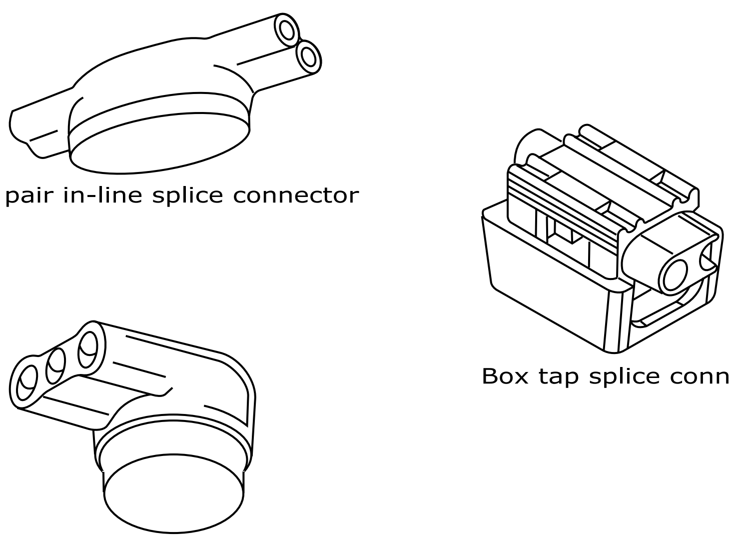
Most balanced twisted-pair cable splicing is performed with modular and discrete connectors.

These connectors are used for OSP or intrabuilding use and, depending on the manufacturer, accommodate 19 AWG [0.91 mm (0.036 in)] to 28 AWG [0.32 mm (0.013 in)] wire. In addition, these connectors are available in several pair sizes (e.g., 1-pair, 5-pair, 10-pair, 25-pair) and should be placed in 1-, 2-, 3-, or 4-bank configurations within the splice. Testing the cable and the splice should be done either during or after construction.

Single connectors (see Figure 6.35):

- Are available in designs capable of terminating two or three conductors.
- Can be filled or nonfilled.
- Accept different gauge wires.
- Require minimum setup time.

Figure 6.35
Example of single-pair splice connectors and modules

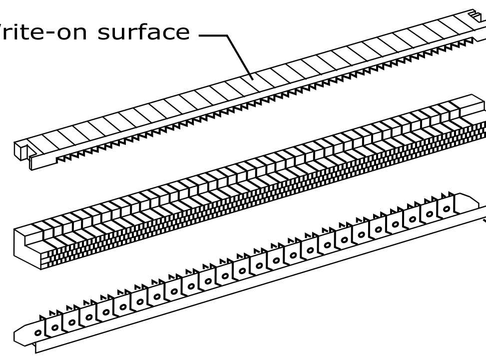


Balanced Twisted-Pair Splices, continued

Multipair splicing modules (see Figure 6.36):

- Splice up to 25 pairs.
- Cut off excess conductor as connection is being made.
- Require an equipment investment.
- Produce higher productivity once the setup is complete.

Figure 6.36
Example of multipair splice connectors and modules



Characteristics

Splice characteristics directly depend on the connector type used.

For details on characteristics of certain styles of balanced twisted-pair connectors, refer to Balanced Twisted-Pair Connectors in this chapter.

Requirements regarding mechanical characteristics, transmission performance, installation, and administration of splices can be found in applicable standards and other chapters of this manual.

Advantages and Disadvantages

Splice's advantages are it:

- Is widely used in OSP and premises cabling for connection, splitting, and re-routing of cabling segments.
- Provides a cost-effective method of connection.
- Can be used in a wide range of applications (see Typical Applications).

Splice's disadvantages are:

- Some splice types do not exist in transmission performance categorized versions.
- Additional point of connection in a balanced twisted-pair link or channel may significantly degrade the overall link or channel transmission performance.
- Balanced twisted-pair splices are not permitted in structured cabling horizontal subsystems and backbone subsystems with maximum link or channel length ≈90 m (295 ft)/≈100 m (328 ft) intended to support high-speed applications (with operation frequency range beyond 1 MHz).

Nonmechanical Firestop Systems, continued

Putty is an excellent choice for applications in small- to medium-sized openings where future entry is required. Most nonhardening putties can be removed to allow for future cable MACs and can be replaced after these modifications are made.

Firestop putty is also available in the form of a pad. The pad is used to seal the back of telecommunications outlet/connector boxes or other electrical fixtures installed in a membrane penetration.

Testing indicates that the putty pad resists flame propagation, smoke movement, and undesirable heat transfer through walls.

The pad:

- Seals knockouts and openings in the fixture.
- Prevents smoke and fire from entering hollow wall cavities.
- Insulates and minimizes heat transfer through the wall.

Putty pads are also used to comply with building code requirements for boxes to allow for variations in box size, spacing, and density within a given wall area.

Some typical uses include:

- Reducing the horizontal separation of boxes on opposite sides of the wall to less than ≈600 mm (24 in).
- Increasing the size of individual boxes to exceed ≈10,000 square millimeters (mm^2 [16 square inches (in^2)]).
- Increasing the aggregate area of boxes in excess of ≈65,000 mm^2 (100 in^2) per ≈9.3 square meters (m^2 [100 square feet (ft^2)]) of wall space.

Putty pads have excellent sound attenuation properties. The use of putty pads on boxes can impede sound transmission through walls. Putty pads are commonly available to fit a standard 4S box, but several manufacturers provide pads with larger dimensions.

When selecting a putty pad, tackiness of the material is desirable. Certain clay-based products can dry out over time, thereby allowing pads installed within wall cavities to fall away from the box or fixture. Adhesion of butyl rubber-based pads is virtually unaffected over time.

Nonmechanical Firestop Systems, continued

Caulks or Sealants

Several firestop materials are available in caulk or sealant form. All of these materials:

- Cure after a relatively short time to form a tight seal.
- Are dispensed either from standard caulk tubes, rolled packages (e.g., sausages, foil packs), or large pails.

The types of caulk vary somewhat in:

- Their ability to adhere to various surfaces.
- Their flexibility and moisture resistance.
- The quantity required for a rated firestop seal.

WARNING: Do not use solvent-based caulk seals that may give off toxic or noxious fumes in confined areas that are not well ventilated.

Firestop caulks may vary in composition and may be:

- Latex based.
- Water based.
- 100 percent solid.
- Solvent based.
- Self-leveling or nonsag.

Some of these materials are:

- Intumescent.
- Endothermic.
- Ablative.

Some caulking materials can be installed from the underside of an opening without dripping or slumping. A self-leveling type is available for application as the topside of a firestop.

Firestop caulk or sealant is a good choice for permanent installations in small- to medium-sized openings (e.g., conduit penetrations, cables, and cable trays that will not be disturbed). Caulks and sealants are economical; however, since caulks and sealants dry or cure, removal for future reentry requires cutting into the seal.

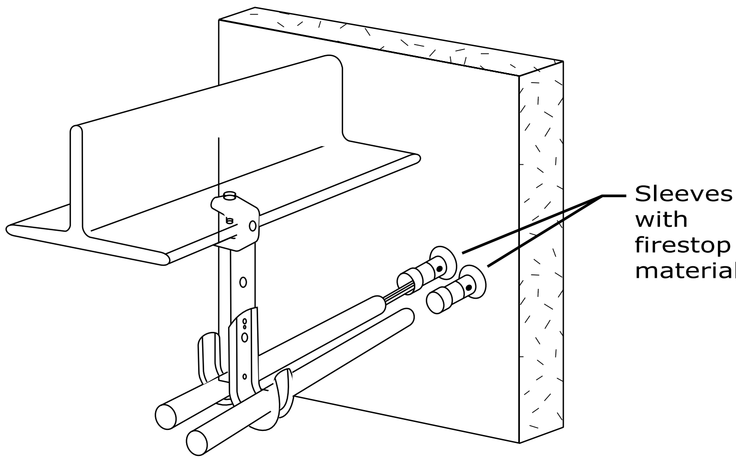
Cementitious Materials

Some firestop materials are available in a cementitious form. These materials are:

- A dry powder.
- Premixed or mixed with water.
- More adaptable to large openings than putty or caulk.

Sleeve System Methods, continued

Figure 7.18
Sleeve system with cable support



Benefits of a sleeve system include the following:

- Ease of installation
- Supports and protects cables being installed
- Packed with mineral wool or ceramic fiber and intumescent fill material
- Reenterable

Electrical Apparatus, Access Panels, Fixtures, and Miscellaneous Recessed Boxes

An electrical apparatus should not penetrate framed walls, which is not qualified for use in fire-rated assemblies with:

- Individual penetrations exceeding ≈10,000 mm² (16 in²) in surface area of one face of a stud wall.
- Multiple penetrations exceeding ≈65,000 mm² (100 in²) of total surface area per ≈9.3 m² (100 ft²) of wall area.

Provide these penetrations with:

- Additional layers of framed wall to maintain the required fire-resistance rating.
- An enclosure of framed wall within the stud space if the wall is load bearing.
- A third-party listed and labeled product tested for the specific condition (e.g., putty pad, protective wrap system).

Electrical Apparatus, Access Panels, Fixtures, and Miscellaneous Recessed Boxes, continued

Electrical boxes that do not exceed ≈10,000 mm² (16 in²) in surface area but create membrane penetrations in a stud wall should be:

- Separated on opposite faces of walls by a horizontal distance of at least ≈0.6 m (2 ft). Plaster-patched tightly to the adjacent board (e.g., if the gap between the box and board does not exceed ≈3.2 mm [1/8 in]).
- Sealed to provide smoke and thermal protection.

Install partial wall penetrations by an access panel or recessed box according to the guidelines for:

- Membrane penetrations.
- Individual penetrations.

Cable Trays

Through penetrations for cable trays shall be:

- Framed out with studs when installed in framed walls.
- Sealed with a firestop system that is:
  - Qualified.
  - Installed according to the manufacturer's instructions.

Ohm's Law, continued

The formula for Ohm's law always applies to dc circuits, but it only applies to ac circuits that are purely resistive (e.g., incandescent lamps, resistive heating elements).

However, many ac circuits (e.g., communications and data processing) have reactance (X) as well as resistance. Reactance is expressed in ohms and is the opposition to the flow of ac current caused by inductance and capacitance.

The net reactance is equal to the difference between capacitive and inductive reactance. This reactance can be combined with the resistance to calculate the impedance (Z), which is the total opposition to ac current flow and is measured in ohms.

The formulas to find Z are:

- When volts (V) and amperes (I) are known:
  $$Z = V/I$$
- When resistance (R) and reactance (X) are known:
  $$Z = \sqrt{R^2 + X^2}$$
- When resistance (R), inductive reactance (X_L), and capacitive reactance (X_C) are known:
  $$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

Inductive Reactance (X_L)

Inductive reactance (X_L) is the portion of impedance that opposes a change in current flow because of magnetic field coupling. Because conductors in balanced twisted-pair cabling are in close proximity, together their mutual inductance has an impact on X_L and therefore the impedance of the circuit.

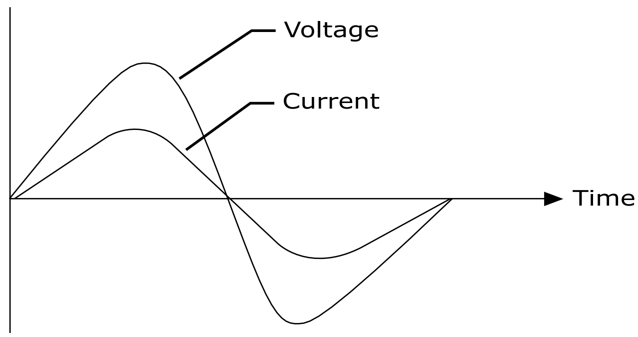
Capacitive Reactance (X_C)

Capacitive reactance (X_C) is the portion of impedance that opposes a change in voltage because of electric field coupling. Because conductors in balanced twisted-pair cabling are in close proximity, together their mutual capacitance has an impact on X_C and therefore the impedance of the circuit.

Power

Power is an important characteristic of ac circuits. In ac circuits that are purely resistive, the current and voltage sine waves are in phase (see Figure 9.9), and the power is calculated by the formula $P = V \times I$.

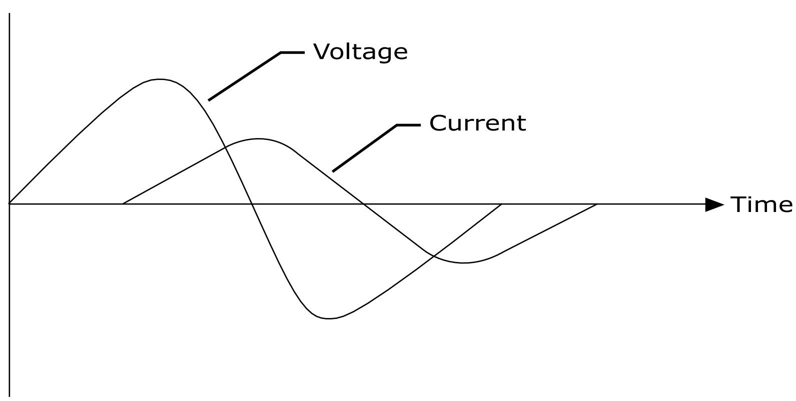
Figure 9.9
Voltage and current in phase (resistive load)



However, in most ac circuits, there is a reactive component that causes the current to lead or lag the voltage waveform.

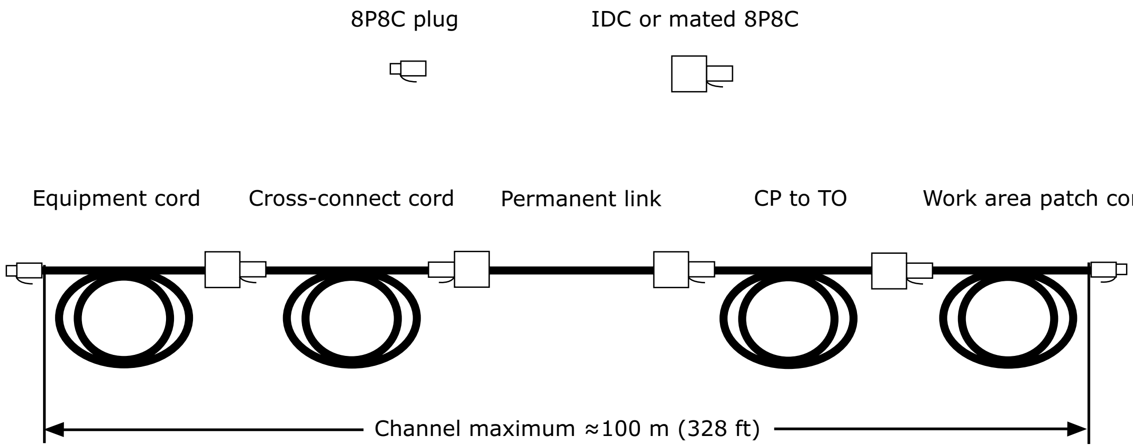
In a circuit with inductive reactance (X_L) there is a lag between the time the voltage waveform passes through zero and the time the current waveform passes through zero (see Figure 9.10). This lag in time is determined by the amount of inductance.

Figure 9.10
Current lags voltage (inductive circuit)



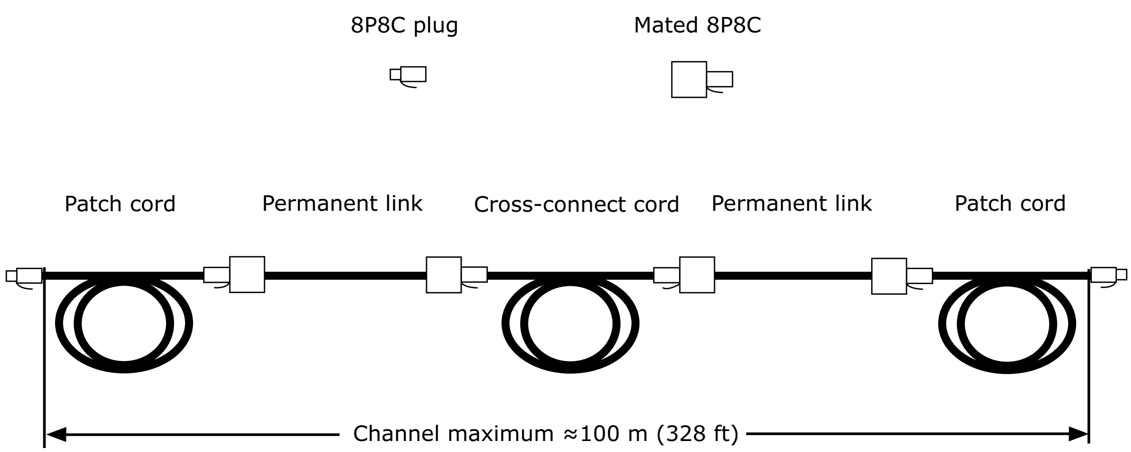
Overview, continued

Figure 11.10
Typical work area four-connector channel



8P8C = 8-position, 8-contact
CP = Consolidation point
ft = Foot
IDC = Insulation displacement contact
m = Meter
TO = Telecommunications outlet

Figure 11.11
Typical data center four-connector channel

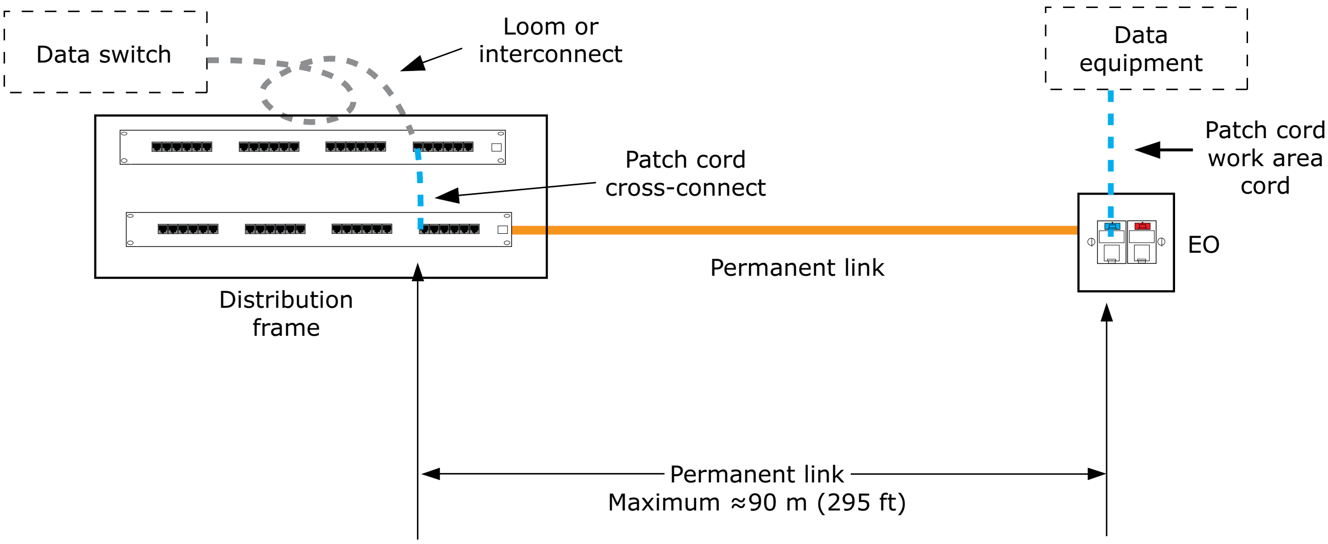


8P8C = 8-position, 8-contact
ft = Foot
m = Meter

Overview, continued

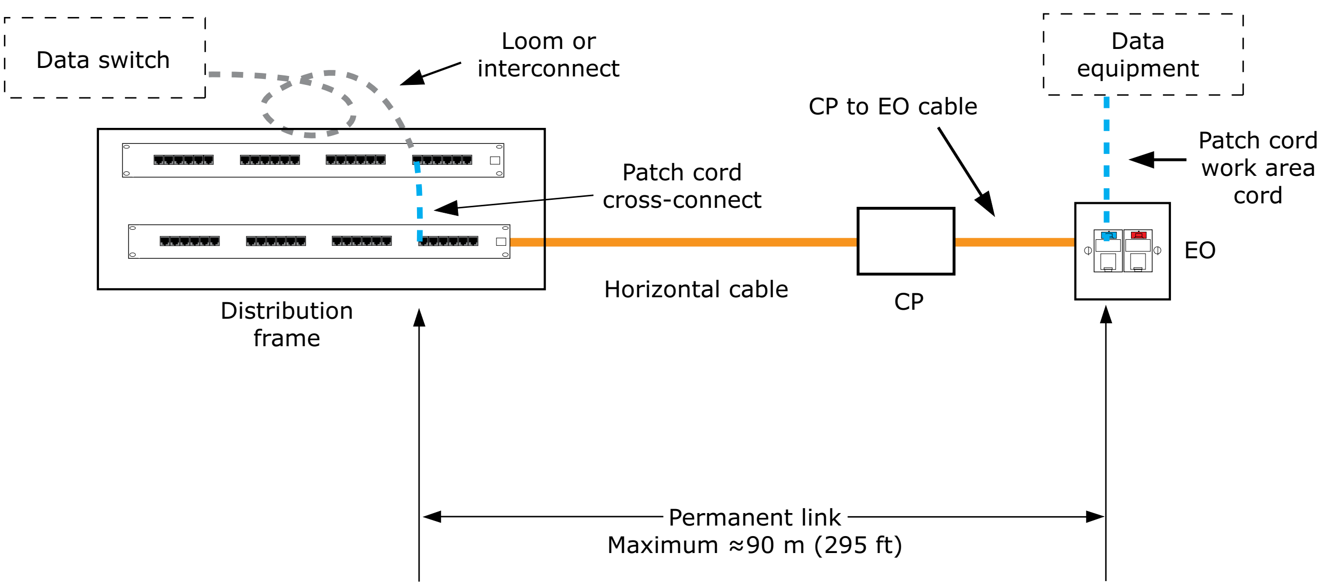
Figures 11.12 through 11.14 demonstrate typical examples for three- and four-connector permanent link models showing the permanent link testing points.

Figure 11.12
Work area three-connector permanent link



EO = Equipment outlet
ft = Foot
m = Meter

Figure 11.13
Work area four-connector permanent link



CP = Consolidation point
EO = Equipment outlet
ft = Foot
m = Meter

Backbone Cabling

Backbone cabling may involve lengths greater than horizontal cabling. For backbone lengths and channels that do not exceed the length limits for horizontal cables, use the test limits for horizontal cabling.

Where backbone cabling exceeds cabling lengths for the same performance or design of product used in horizontal cabling, fundamental tests should be considered when testing:

- Continuity
- Wire map/strand identification

Other test requirements may have to be run to confirm that the backbone cabling is suitable to carry the required application. The details for these tests will be set out in the application requirements or cabling standards.

Open Office Cabling

Open office cabling may include a multiuser telecommunications outlet assembly (MUTOA) or a consolidation point (CP). Often the cabling to the MUTOA or CP is installed before the office is completed and may require field testing.

Testing to a MUTOA or CP (known as the CP link) is subject to permanent link test requirements. For example, the CP link comprises horizontal cabling from the patch panel in the equipment room (ER) to the CP. The pass/fail limits are based on up to ≈90 m (295 ft) horizontal cable plus two connectors. The permanent link, including the CP, should be tested after installation of the open office cabling.

Shielded Cabling

For all shielded cabling, test shield continuity in addition to the required tests. This test, however, does not determine the effectiveness of the shield, which is best evaluated in the laboratory. When testing shielded cabling, ensure that the field test instrument is appropriately configured and that the cords used also are shielded. The shield effectiveness of installed shielded cabling systems may be demonstrated using the alien crosstalk test procedures.

Coaxial Cabling Testing

Overview

Coaxial cabling is used in broadband applications and, in the past, on LANs. Coaxial cable is a low-impedance media (50 or 75 ohm) with a single transmission path.

The tests performed most often are:

- Direct current loop resistance.
- Impedance.
- Length.
- TDR.
- Noise.

The required tests or acceptance tests depend on the application.

Air Dielectric Cabling Tests

50-ohm air dielectric coaxial cable is the primary cabling used in a distributed antenna system (DAS).

Two devices are needed to successfully test the cabling system:

- 50-ohm cable tester
- Spectrum analyzer

50-Ohm Cable Tester

The 50-ohm cable tester is used for the following functions:

- Test for continuity
- Test for attenuation
- Test for TDR impedance
- Test for voltage standing wave ratio
- Provide pass or fail test results

The tester should be calibrated in accordance with manufacturer specifications.

Spectrum Analyzer

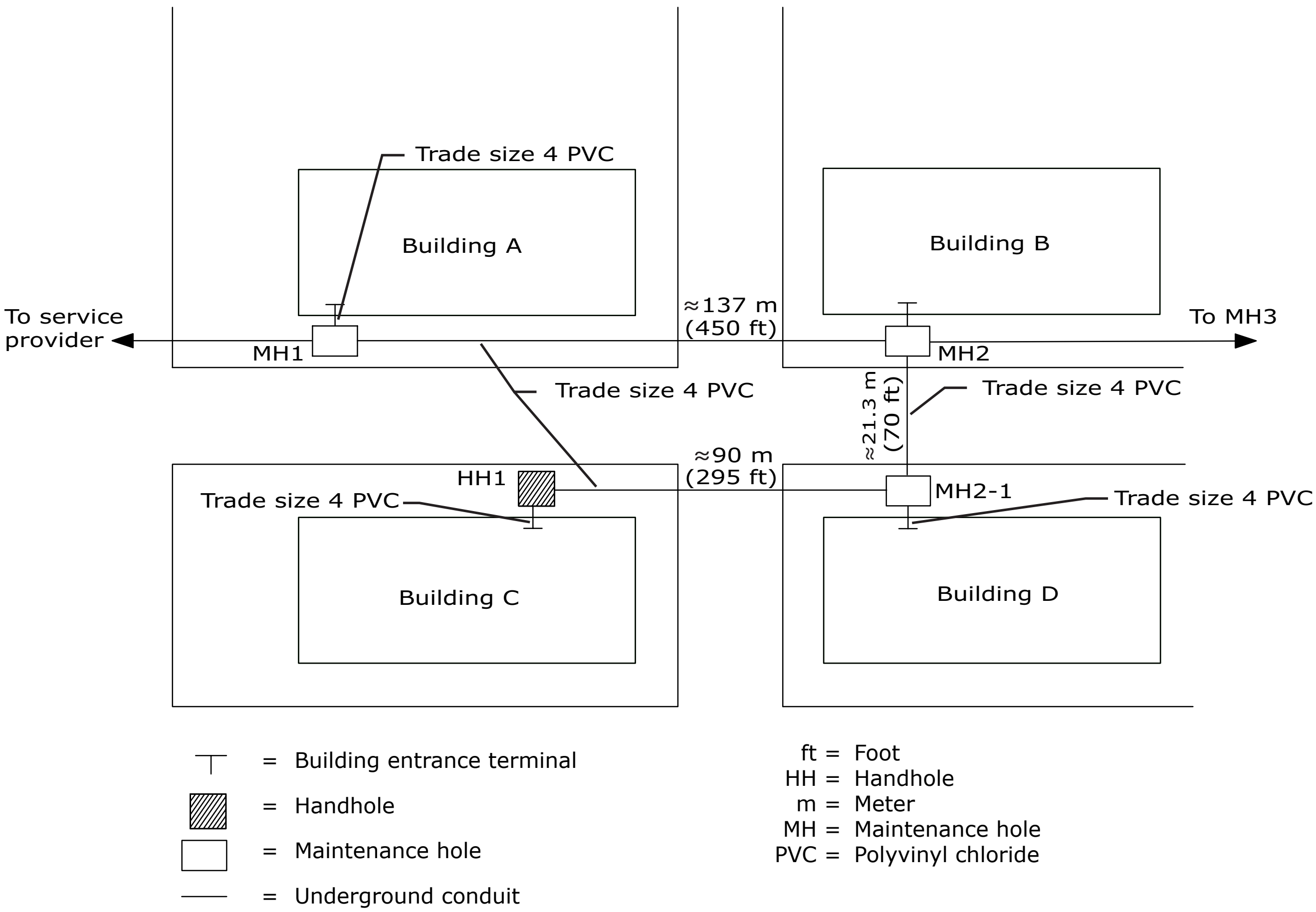
The spectrum analyzer will display the power spectrum over a given frequency range in real time. The tester is also used to test for received signal strength indication levels. This test will assist in the identification of areas that need additional antennas to produce successful coverage.

The spectrum analyzer also is used to test for interference and for the desired output level in comparison with the surrounding spurious signals, which may cause interference of radio communications.

Underground Pathways, continued

Figure 12.1 illustrates an underground pathway plan.

Figure 12.1
Underground pathway plan



NOTES: Locate MHs out of roads for traffic and safety considerations.

See BICSI's *OSPDRM* for right-of-way and easement information when designing routes in the public domain.

Types of Entrances

Overview

Although optical fiber cables are specified in many situations, the most common medium for providing connections to the access provider is balanced twisted-pair cable.

The access provider may bring either of these cable types onto the customer's property through:

- Underground entrances that use conduit to provide out-of-sight service to a building.
- Buried entrances (e.g., trenched, plowed) that provide out-of-sight service to a building without conduit.
- Aerial entrances that provide overhead service to a building, typically from poles.
- Tunnel systems.

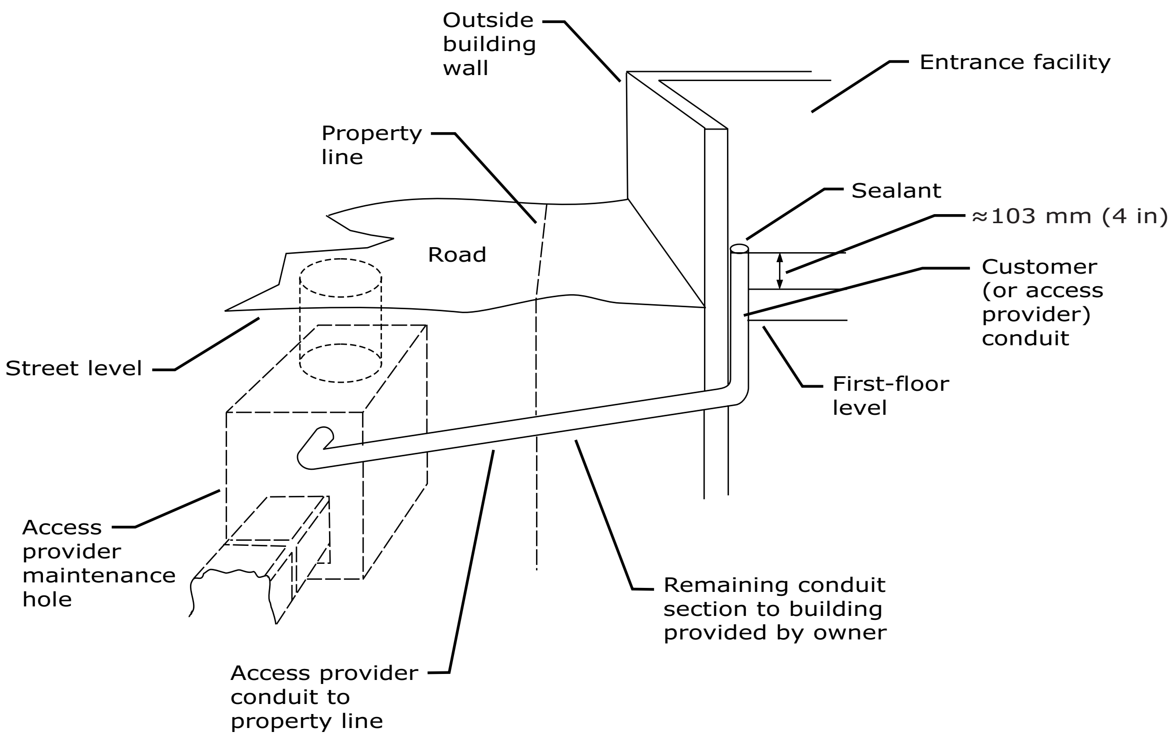
General Recommendations for Underground Entrances

Choosing Pull Points

No more than two 90-degree bends (or a total of 180 degrees) should be designed or installed between pulling points. A 90-degree bend should never be exceeded.

An example is shown in Figure 12.2.

Figure 12.2
Installing underground entrances



When a building is not on the property line, the building owner should provide two or more conduits from a point inside the building to the property line or easement. The access provider will connect its underground conduit to the building owners' conduit at the property line or easement. The size, depth, and location of the conduit must be coordinated with access provider engineers and the building owners' architect.

Buildings without basements must have conduit for access from the property line or easement to inside the building. This minimizes service interruption caused by physical damage and maintains a good appearance. A poured-within-the-slab conduit entrance is designed for this purpose.

NOTE: For information related to regulating bends, reaming conduit, preventing conduit shearing, minimum depth, and encasement, refer to the latest edition of BICSI's *OSPDRM*.

Terminating Conduit at a Designated Property Line

Determining Cover Depth

Terminate underground conduit at the designated property line or easement with a minimum cover of ≈600 mm (24 in).

NOTE: Check local codes for additional requirements. In cold climates, minimum burial depth may be greater based on the posted 50/100-year freeze point, if applicable. Coordinate depth with the access provider.

Preparing for Tie-In Connections

The access provider will make the proper tie-in connections at the designated property line termination. The end of the conduit should be wrapped or plugged with a suitable material to prevent clogging until the cable or additional conduit is placed.

The end of the conduit should be flagged to designate the point of connection between the AP and the entrance conduit. A typical connection between the AP and an owner-provided conduit is shown in Figure 12.2.

Terminating Conduit Inside a Building

Designing Termination Points

The ITS distribution designer should design conduits entering from:

- Below grade point to extend ≈100 mm (4 in) above finished floor (AFF).
- Ceiling height to terminate ≈100 mm (4 in) below the finished ceiling.

NOTE: The ≈100 mm (4 in) penetration is specified for EFs, as opposed to the ≈25 mm (1 in) to ≈75 mm (3 in) penetration specified for intrabuilding conduit.

Fastening Entrance Conduits

All entrance conduits should be securely fastened to the building so they can withstand a typical placing operation performed by the access provider.

The area around an entrance conduit should be kept free of any construction, storage, and mechanical apparatus.

Sealing Conduits

The end inside the building and the pole or MH end of a conduit should be sealed to prevent rodents, water, or gases from entering the building. Use rubber conduit plugs, a water plug, or duct sealer depending upon the conditions.

Unlisted innerduct extending into the building must be terminated and firestopped. Reseal conduits after or when additional cable is placed in them.

Bonding and Grounding (Earthing)

Requirements

All cables entering a building must conform to the bonding and grounding (earthing) requirements described in the applicable codes, standards, and regulations.

NOTE: See Chapter 8: Bonding and Grounding (Earthing) for additional details.

Buried Entrances

Identifying Subsurface Facilities

All subsurface facilities (e.g., electric power, gas, water, outdoor lighting) should be identified before trenching to avoid damage. The local underground utilities center (e.g., One Call Center [in the United States]) should always be called before digging. The building owner should be consulted about sprinkler systems, outdoor lighting, or other facilities buried on private property. A means shall be provided to identify conduit ends adjacent to a building (e.g., locator ball, flags) so the access provider can identify them.

Clearing Foundation Landscaping

All conduit stubs entering the building should be designed to extend beyond the foundation landscaping.

Requirements for Direct-Buried Methods

In most locations, the access provider requires right-of-way permits or easements before placing EFs by the direct-buried method. Local policies and tariffs may specify charges for trenching and backfilling on private property when the access provider completes the work.

Shoring Requirements

BICSI recommends that any trench ≈1.52 meters (m [5 feet (ft)]) or more deep must:

- Be shored, sloped, or stepped (benched) to prevent cave-in.
- Have a minimum clearance of ≈0.6 m (2 ft) from the edge of the excavated dirt pile to the nearest edge of the trench.

Refer to the local AHJ or Occupational Safety and Health Administration for safety regulations.

Avoiding a Sunken Trench

When refilling a trench, the earth should be tamped properly to avoid a sunken trench appearance later. The areas should be revisited to ensure that the trench is solid with the surrounding undisturbed earth.

Small-Diameter Cable Drop

In the small-diameter drop method of attaching an aerial cable to a building, a drop hook attached to a conduit mast supports the cable.

A conduit mast can:

- Terminate in a protector box mounted on the exterior wall.
- Enter the building through the roof.

Use small-diameter drops only for minimal circuit requirements. Where the cable enters the building, it must be sealed from rodents, moisture, and insects with the appropriate material.

Vertical Conduit Masts

Aerial cable must enter a building through a raceway (e.g., conduit or sleeve) with an approved service head.

A vertical conduit may either:

- Terminate in a protector box mounted on the exterior wall.
- Enter the building through the roof.

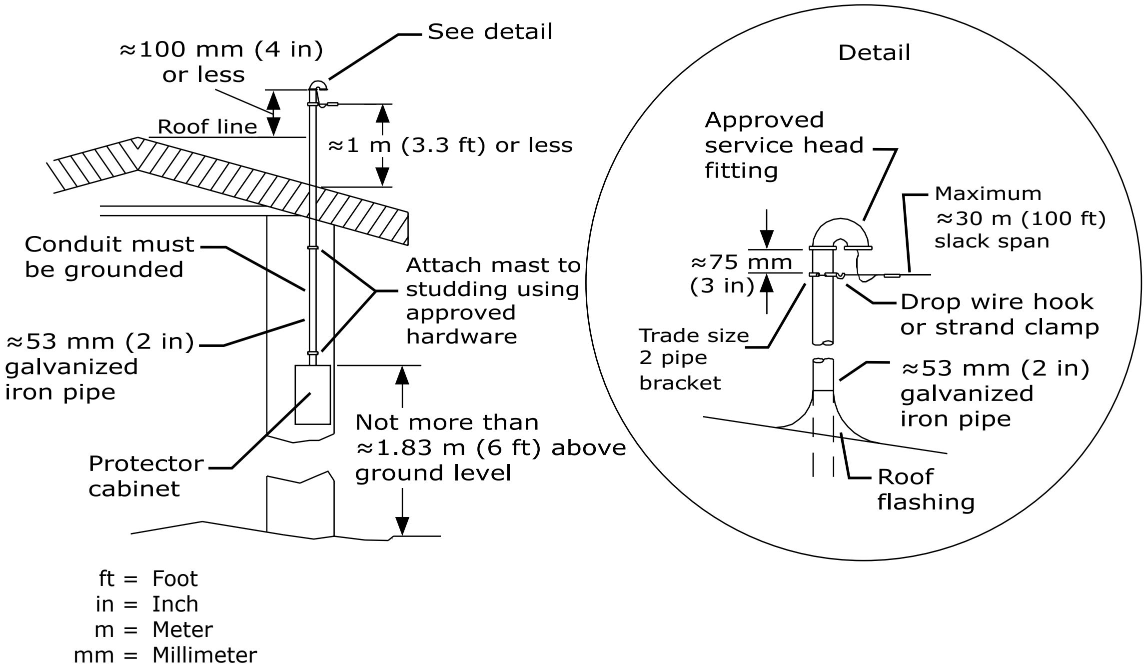
Figure 12.4 illustrates how a typical vertical conduit mast may enter the building.

NOTES: To ensure proper support, do not extend the mast more than 100 mm (4 in) above the roof line.

Where the cable enters the mast, the mast must be sealed from rodents, moisture, and insects with the appropriate material.

Vertical Conduit Masts, continued

Figure 12.4
Vertical conduit mast



NOTES: Iron pipe must be effectively grounded (see Chapter 8: Bonding and Grounding [Earthing]).

This arrangement is limited to drop-wire attachments of up to four lines.

The service mast must be sufficiently high to provide drop-wire clearance over sidewalks, streets, or roadways in compliance with codes, standards, and regulations.

Where the cable enters the pipe, the pipe must be sealed from rodents, moisture, and insects with the appropriate material.

Terminating Space for Telecommunications Entrance Facilities

Requirements for Inside Space

Space provided for terminating EFs inside a building must be well planned. Use this space for electrical protection and cable distribution.

Terminating space must be physically protected. Standard posts, bollards, or barriers help to protect the termination equipment when placed in locations where motor vehicles or other moving equipment is used (e.g., in a garage).

In such cases, the posts (or bollards) should be:

- A minimum of ≈103 mm (4 in) in diameter.
- Filled with concrete.
- Encased to a minimum depth of ≈900 mm (36 in).
- Extended a minimum of ≈1067 mm (42 in) AFF.

Terminating space must be equipped with an AC grade or better, void-free plywood backboard, ≈2.4 m (8 ft) high with a minimum thickness of ≈19 mm (0.75 in), securely fastened with the grade C surface facing the supporting wall.

BICSI recommends the terminating space shown in Table 12.2.

Table 12.2
Terminating space

Gross Floor Space Served (m^2 [ft^2])	Wall Length (mm [in])
≈929 (10,000)	≈1000 (39)
≈1858 (20,000)	≈1067 (42)
≈3716 (40,000)	≈1727 (68)
≈4645 (50,000)	2286 (90)
≈5574 (60,000)	≈2400 (96)
≈7432 (80,000)	≈3050 (120)
≈9290 (100,000)	≈3658 (144)

ft^2 = Square foot
in = Inch
m^2 = Square meter
mm = Millimeter

Requirements for Inside Space, continued

The backboard should be painted with at least two coats of fire-retardant paint. Fire-retardant plywood is also acceptable except in nuclear power plants or other restrictive locations. BICSI recommends either fire retardant plywood or regular plywood painted on all sides with fire retardant paint.

Allocate additional backboard space for multiple network interface (NI) units at the access provider's minimum point of presence only if local tariffs or practices permit.

Terminating space should be located in a dedicated area of an entrance room (ER) or a telecommunications room (TR) if a separate room is not allocated for EFs. Buildings larger than ≈9290 m^2 (100,000 ft^2) must contain a dedicated room for EFs. The size of the room is determined by the:

- Type of facility.
- Terminating hardware selected.
- Necessity for electrical protection.

The door to the dedicated room should:

- Open outward (e.g., if local building codes permit).
- Have the same fire rating as the room wall.
- Not be less than ≈0.91 m (3 ft) wide by ≈1.98 m (6.5 ft) high.

Larger buildings require close coordination with the access provider and the customer's telecommunications vendor.

Cabling Placement

Planning and Design Factors

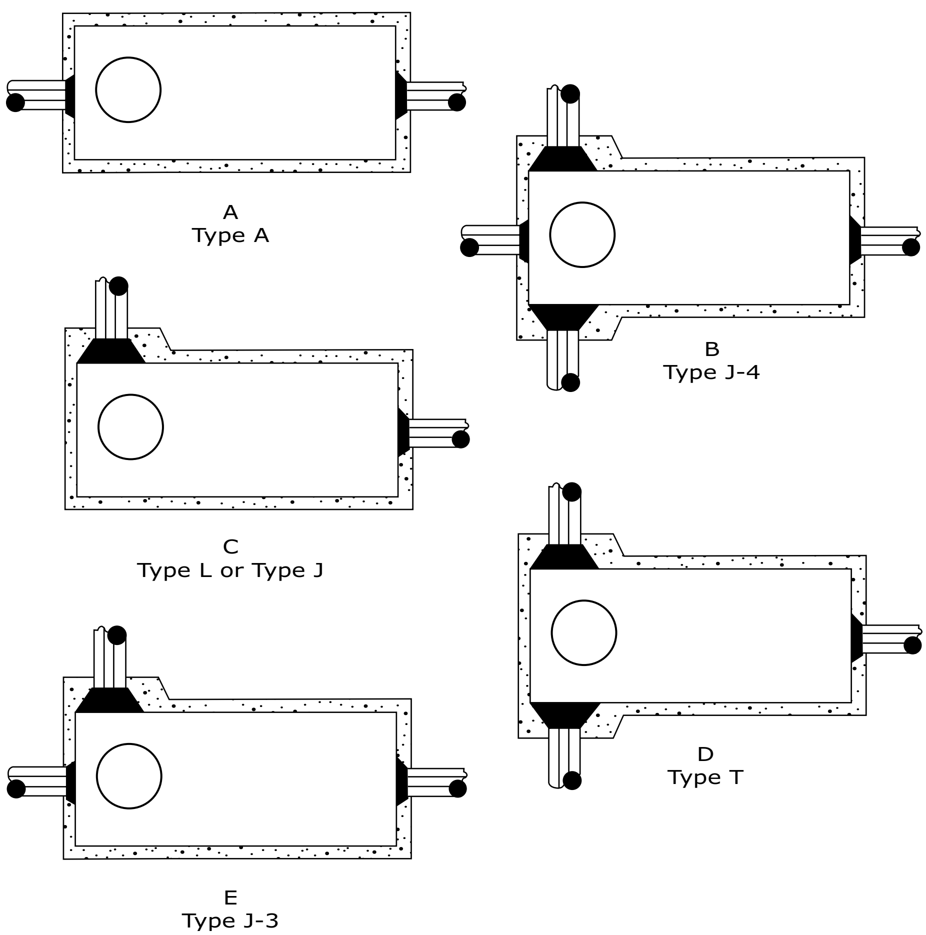
In any MH system, the MHs must be:

- Sized to meet the maximum conduit requirements.
- Located to optimize the use of the associated conduit routes.

Basic Maintenance Hole (MH) Configurations

Figure 12.11 illustrates overhead views of five basic MH configurations.

Figure 12.11
Basic maintenance hole configurations

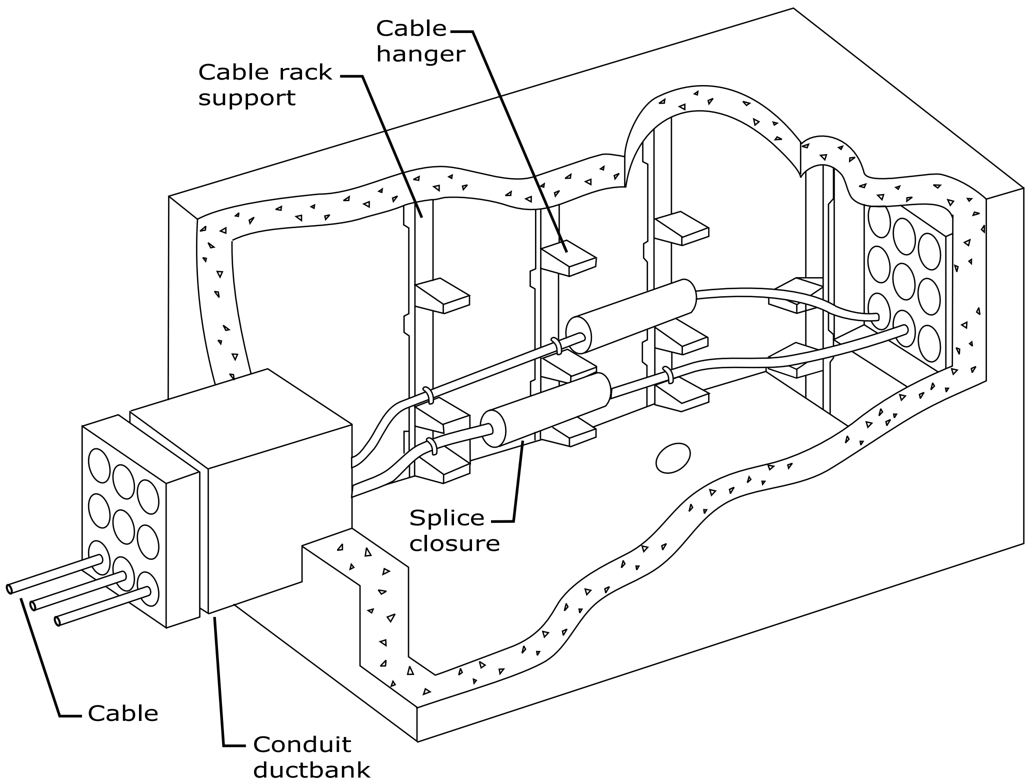


NOTE: For further explanation, see BICSI's *OSPDRM*.

Typical Cable Maintenance Hole (MH)

Figure 12.12 illustrates a cutaway view of a typical cable MH.

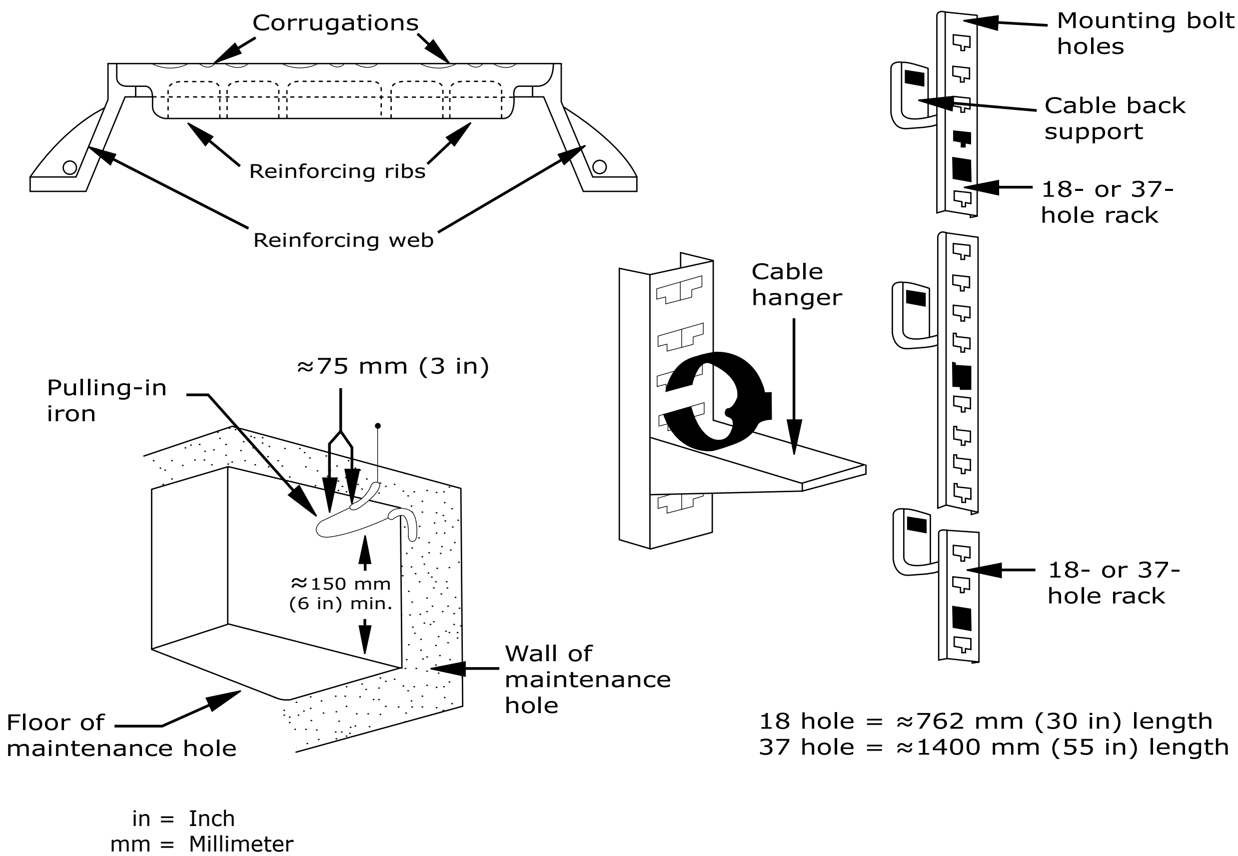
Figure 12.12
Typical cable maintenance hole



Maintenance Hole (MH) Hardware

Figure 12.13 illustrates the elements of an MH.

Figure 12.13
Maintenance hole racking



MHs can be ordered or constructed with a wide variety of configurations. Each MH may be referred to using a simple one-letter designation such as type A, type J, type L, and type T.

NOTE: Refer to the latest edition of BICSI's *OSPDRM* for further clarification.

Aerial Plant Criteria

Planning and Designing Guidelines

The following are suggested planning and designing guidelines for aerial plant:

- Consider an aerial design if a buried design is significantly more expensive or is not feasible due to temporary area construction.
- Select permanent locations for pole lines while considering:
  - Future road widening or realignment.
  - Expansion of other utilities.
  - Special problems (e.g., road, railway, and power line crossings).
  - Safety and convenience of workers and the general public.
- Obtain necessary permits and easements for:
  - Building and maintaining pole lines on private property and public right-of-way.
  - Crossing railroads.
  - Crossing over navigable waterways.
- Coordinate with other utilities with respect to possible inductive interference.
- Design pole line for ultimate needs, considering:
  - Pole-line classification.
  - Storm loading.
  - Clearance requirements.
- Use the most economical span length within the constraints imposed by the design guidelines while allowing for maximum growth of future interoffice cable feeders.
- When adding cable to an existing line or when establishing a joint-use line, check that the pole strength and clearances are adequate.
- Existing pole-line owners:
  - May require makeready work to provide space for new cable.
  - Usually require reimbursement for any expenses incurred preparing the pole line.
- Use self-supporting cable rather than lashed cable if:
  - It is available in the required size.
  - There is no existing strand.
  - New cable cannot be lashed to an existing cable.
  - Adequate space exists for future growth.

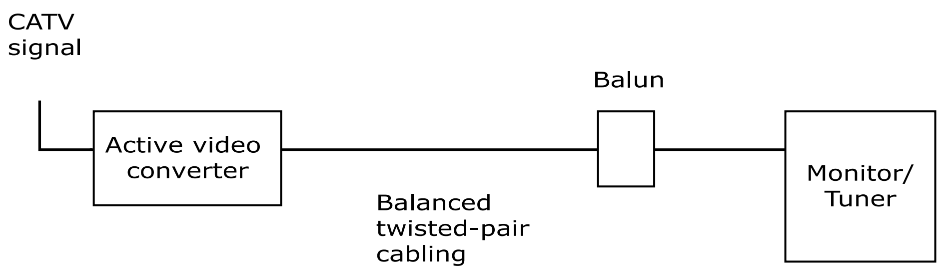
Suspension strand and cable should usually be placed on the roadside of the pole line. However, the field side should be used if a known road is moved to where a cable line will be relocated.

Other Distribution Systems

Video Over Balanced Twisted-Pair Cabling

Broadband video over balanced twisted-pair cabling has become ever more popular in the development of extended frequencies over balanced twisted-pair cabling. Most manufacturers can archive 86 channels or up to 550 MHz on balanced twisted-pair cabling (see Figure 13.44).

Figure 13.44
Video over balanced twisted-pair cabling



CATV = Community antenna TV

The issues regarding video over balanced twisted-pair cabling are:

- Video is designed to transmit over 75 ohm coaxial cable. This is corrected by the use of balanced to unbalanced matching transformers called baluns. The balun is designed to convert from 75 ohm unbalanced coaxial to 100 ohm balanced twisted-pair cabling category 5e or better.
- The degradation of the signal is determined by the loss of the cable and passive hardware, which is corrected by the use of active components. Most manufacturers use the same structured cabling length of ≈90 m (295 ft) as the maximum distance from the active component to the TV or monitor.

Some additional considerations are:

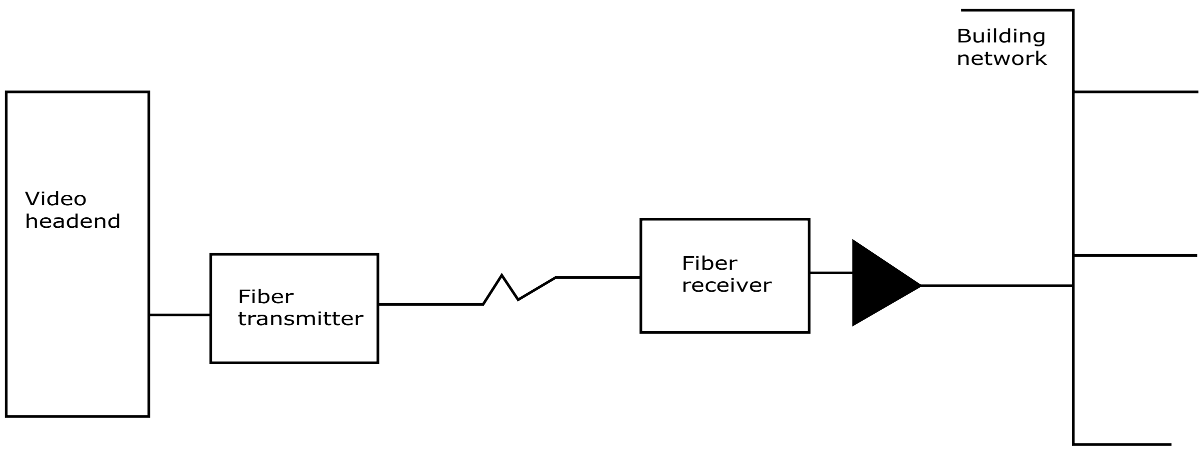
- Flexibility.
- A building structured cabling system that can be used as transmission media.
- No loss calculation required.
- Cost.
- Maintenance.

Other Distribution Systems, continued

Video Over Fiber Optical Cabling

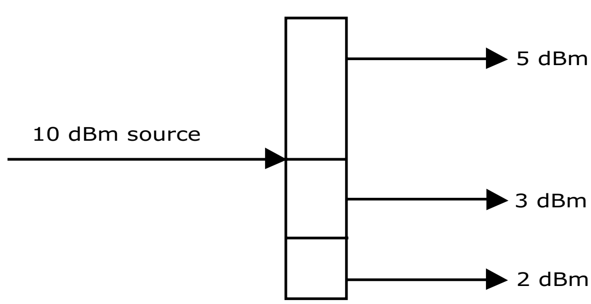
The transmitter performs the conversion of analog video signals to photons (e.g., light signals). A receiver on the far end receives the optical signal and converts it back to an electrical signal (see Figure 13.45). The principle of transmitting video over optical fiber cabling is similar to transmitting data over optical fiber cabling. This principle has become practical in long-distance video applications. The signal loss in optical fiber is substantially less than in coaxial cable, which allows for the greater distance. The use of optical fiber cable to run the signal from one common video headend is a practical application.

Figure 13.45
Video over optical fiber cabling



The use of optical couplers/splitters also can enhance a video network. An optical coupler/splitter divides the optical signal into different percentages of the source signal (see Figure 13.46). When the splitter is ordered, specify this percentage (e.g., 50 percent, 30 percent, 20 percent).

Figure 13.46
Dividing the optical signal



dBm = Decibel milliwatt

To determine the percentage of each port of the splitter, use the optical loss of the cable lengths. The cable with the most loss requires the largest percentage of the signal.

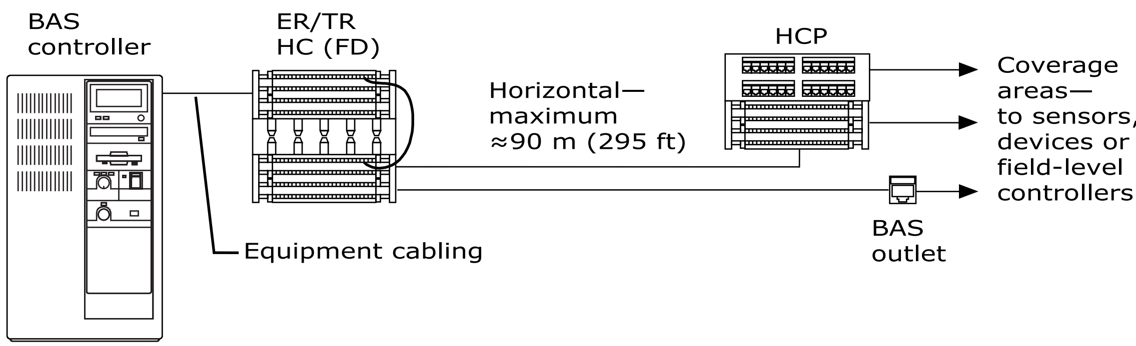
Telecommunications Cabling Structure Elements

The following information on cabling elements is provided to show some general guidelines and design consideration when connecting BAS equipment and devices to the telecommunications cabling distribution system (see Figure 14.5).

Design considerations for integrating BAS with the telecommunications cabling distribution system are discussed for the following cabling elements:

- Coverage area
- Horizontal connection point (HCP)
- Horizontal cabling
- Backbone cabling
- Equipment cabling
- Cabling pathways

Figure 14.5
Cabling system elements and channel



BAS = Building automation systems
ER = Equipment room
ft = Foot
HC (FD) = Horizontal cross-connect (floor distributor)
HCP = Horizontal connection point
m = Meter
TR = Telecommunications room

Telecommunications Cabling Structure Elements, continued

Coverage Area

The coverage area is the area served by a BAS device. This element of telecommunications cabling can be compared to the voice and data work area.

The BAS device can be connected to the horizontal cabling in a star topology using the following methods:

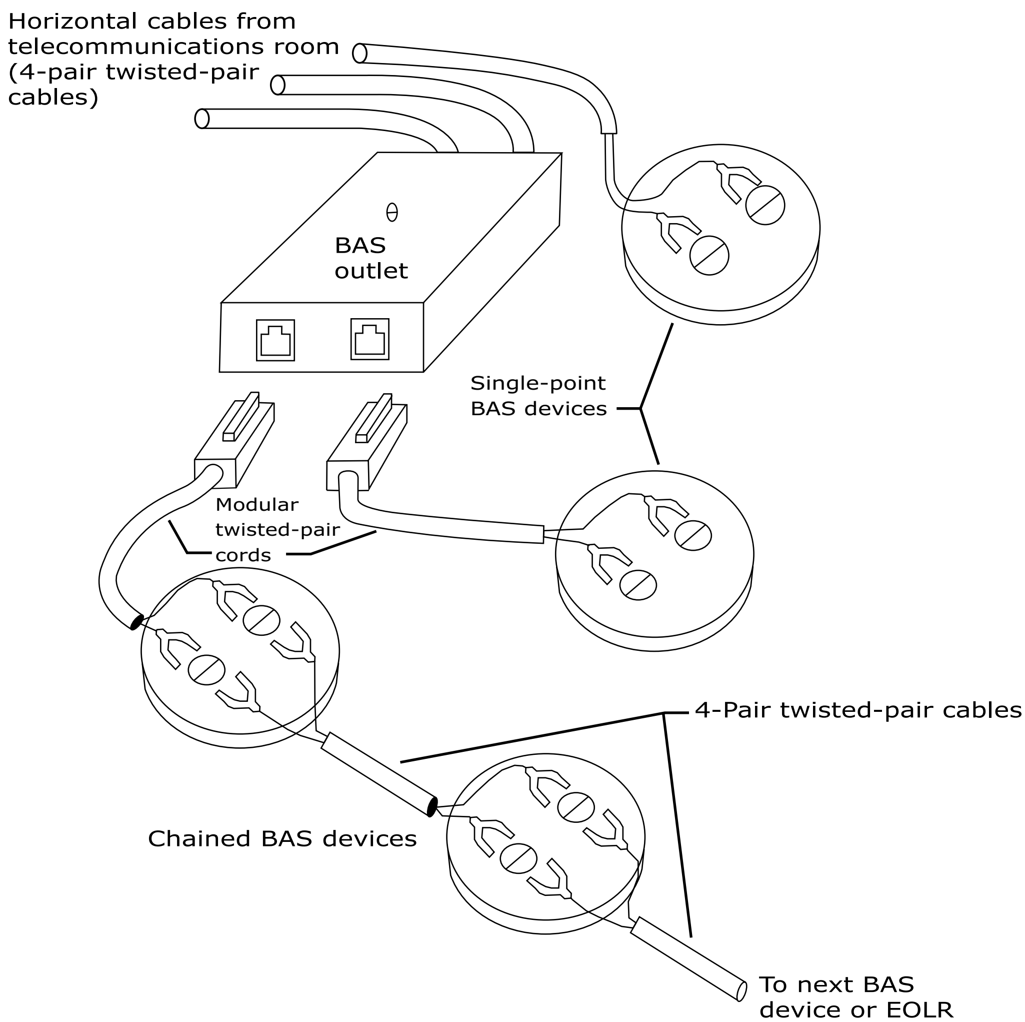
- A coverage area cable and a BAS outlet
- A coverage area cable and an HCP
- The horizontal link directly terminated on the BAS device connector

NOTE: When hardwiring balanced twisted-pair telecommunications cabling to a BAS device, it may be necessary to use spade tips or sleeve connectors to interface the cable conductors to the terminal strip. Follow the cable manufacturer's specifications for terminating the cable, and use an approved connector that properly fits the terminal strip connection of the device. Typically, large diameter conductors (e.g., 16 AWG [1.3 mm (0.051 in)] to 22 AWG [0.64 mm (0.025 in)]) can be directly connected to the terminal strip without the use of additional connectors.

Telecommunications Cabling Structure Elements, continued

Unlike the voice and data work area, BAS cabling infrastructure allows different coverage area topologies, which means that the coverage area may be extended to connect multiple devices or field-level controllers on the same horizontal cable run (e.g., chained, bridge connection, or multipoint branch [bus or ring]). If a BAS outlet is mounted in plenum areas, it may require placement in an enclosure or junction box if the outlet is not plenum rated. Examples of a single-point branch using a modular and a hardwired connection and a chained branch are provided in Figure 14.6.

Figure 14.6
Single-point and chained branch devices



BAS = Building automation systems
EOLR = End-of-line resistor

NOTE: An end-of-line resistor (EOLR) may be connected to the last device in a branch or chain to supervise or monitor a low-level current to detect a short or a break in the circuit. This implementation is typically used in nonintelligent FA or security circuits that require supervision.

Telecommunications Cabling Structure Elements, continued

If the device locations are unknown, it is possible to calculate the quantity of work areas and coverage areas (e.g., BAS device locations) based on the maximum usage of the size and type of space.

The calculations for this approach involve the following factors:

- Common method for the cable pathway or delivery method (e.g., partitioned raceway, open tray, closed tray, ladder rack, or multiple conduit system)
- Number of systems to be integrated
- Size of the horizontal space (e.g., TR serving area)
- Work or coverage area size requirements

For example, the ITS distribution designer can calculate one:

- Voice and data work area every ≈9.3 m^2 (100 ft^2).
- Coverage area or BAS device every ≈23 m^2 (250 ft^2).

For most building types and sizes, the best way to implement this type of strategy and create a distribution system that can meet the need of any possible end user or device configuration is with the open office or zone cabling approach. If this method of cabling is properly designed, the horizontal cabling from the TR to the zone box containing the consolidation point (CP)/HCP is reusable for the life of the structure. The CP is used for voice, data, and video connections. The HCP is used for BAS services and also may include video (e.g., video surveillance) for security services.

Table 14.1 gives the typical size for the recommended number of work areas and BAS devices for each type of building area.

Door Release Hardware Types, continued

Magnetic Locks

Two general types of magnetic locks are:

- Direct hold (direct-pull).
- Shear locks.

With the direct-hold type, an electromagnet is mounted on the doorframe opposite the metal plate (e.g., strike) known as the armature. When energized, the electromagnet bonds to the armature and locks the door. Normally, a magnetic lock is mounted to the top of the doorframe on the lock edge. The armature is mounted to the door. On direct-hold magnetic locks, the magnet is the primary method of securing the door.

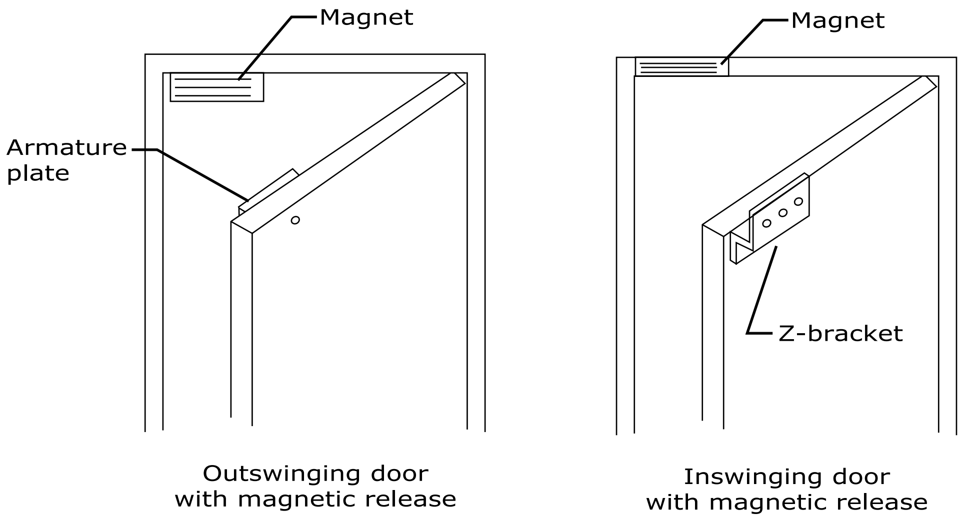
The shear-lock type uses both magnetic and physical properties for locking. In a concealed mounting application, the electromagnetic lock body is mortised into the door's frame, and the armature is mortised into the door edge. Indentations in the armature receive protrusions in the lock body. The combination of these properties considerably increases force. Common considerations are:

- Magnetic locks are fail-safe and may not be used as the only hardware on fire doors (e.g., latching is necessary). However, no other locking hardware may be on the door.
- Magnetic locks are fail-safe, and doors are unlocked in the event of power failure, allowing a potential security breach.
- For egress purposes, some method of release is required from the egress side. Two means of release are normally required by the AHJ. One of the methods shall be a mechanical switch (e.g., not an electronic switch). If a request to exit button is used, the lock shall be a pneumatic type so that the door is released for 30 seconds. It shall be mounted within approximately ≈1.5 meters (m [5 feet (ft)]) of the door at a height between approximately ≈1016 millimeters (mm [40 inches (in)]) and ≈1220 mm (48 in) above finished floor (AFF), respectively.
- If an automatic FA system or automatic sprinkler system is present, magnetic locks should be connected to the system so that the locks release upon alarm activation. The doors shall remain unlocked until the fire protective system is manually reset.

Door Release Hardware Types, continued

- Magnetic locks (see Figure 17.6) are available in a range of holding forces. The greater the holding force, the less susceptible the lock is to attack.
- Adding a magnetic lock to the doorframe as the means of egress may reduce the vertical height from the floor.

Figure 17.6
Magnetic locks



Initiation Devices

This section focuses on the components essential to various configurations of FA system initiation devices. While there are multiple component manufacturers, the basics or fundamentals of the devices generally remain the same.

It should be noted that legalities pertaining to the selection, installation, approval, and integration of components in a FA system shall be strictly adhered to in every case. Conformance protects life and property.

This section includes the following categories of initiation devices:

- Smoke detection
- Heat detection
- Flame detection
- Fire-gas detection
- Human detection—FA pull stations

Detection Devices

Components of a fire consist of:

- Smoke (e.g., particulate, aerosol).
- Heat.
- Light radiation.

Fire detection devices are built to detect one or a combination of these components. While all components are necessary for a fire to exist, all components may not exist at a detectable threshold. Similar non-fire components might exist in the same ambient conditions, which could cause unfavorable false alarm conditions.

Devices used for fire detection include smoke detectors, heat detectors, flame detectors, fire-gas detectors, and other devices:

- Smoke detectors sense visible or invisible particles of combustion generated by burning, smoldering, or the incipient stage of combustion. These devices fall into two categories—photoelectric and ionization.
- Heat detectors sense a high temperature or temperature rise caused by fire.
- Flame detectors sense the radiation produced by fire (e.g., visible light or invisible radiation, IR, ultraviolet radiation).
- Fire-gas detectors sense gases produced by a fire.

Pull Stations

When a person detects fire, they can initiate strategically placed pull stations. Pull stations are simple switches that, when pulled, turn on the FA notification appliances.

Pull stations are available in two types:

- Single action
- Double action

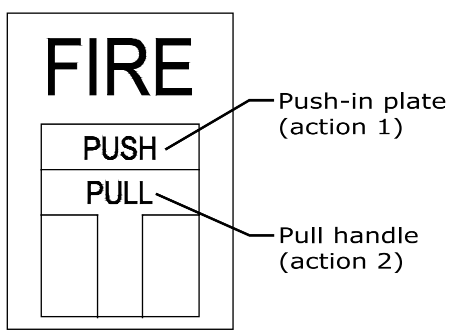
Single-action pull stations are so named because they require one action (e.g., pulling a lever) to initiate the alarm. Double-action pull stations require two actions (e.g., lifting an access door, breaking a glass rod or glass pane, and then pulling the lever to initiate the alarm). This provides a physiological barrier to prevent false alarms.

Sometimes the double-action stations are provided with a telltale to indicate a prealarm or trouble condition if the first action is completed without the following of the lever pull. Refer to Figure 17.11 for a typical pull station.

Pull stations are located within ≈1.5 m (5 ft) of each door that is a point of egress and are strategically placed so that the linear travel distance between pull stations does not exceed ≈61 m (200 ft). Typical mounting heights of pull stations should be ≈1220 mm (48 in) to ≈1370 mm (54 in) above the floor.

All fire alarm devices and locations shall comply with the AHJ.

Figure 17.11
Typical fire alarm pull station



Fire Suppression Systems and Supervision Devices

The ITS distribution designer should understand the relationship between a fire detection and a fire suppression system. While each serves a similar purpose in the protection of life and property, a fire detection system is required to interface with the fire suppression system by using devices designed to monitor (e.g., supervise) the status of this system.

Supervisory devices are the monitoring equipment required for fire suppression (e.g., sprinkler) systems. These devices monitor abnormal conditions in the sprinkler system. Their duties include the supervision of the open or closed positions of control valves supplying water to the system, fluctuation in system air pressure, and temperature/level of water in gravity and pressure tanks (when used).

Technology Equipment Center (TEC)

The TEC houses the main networking equipment and the application servers and data storage devices that serve the building. TEC is the terminology commonly used in the health care design industry and is similar to the equipment room and maintenance center in other environments. The TEC is the heart of the ITS and communication systems for hospitals. The TEC must be sufficiently sized, environmentally controlled, power conditioned, and fire protected.

Number and Size

Each hospital shall have at least one TEC that is used exclusively for data storage, processing, and networking.

The TEC shall be an adequate size to provide the proper space to meet service requirements for the equipment.

Location and Access Requirements

The TEC shall be located above any floodplains and below the top level of the facility to deter water damage to the equipment from outside sources (e.g., leaks from the roof, flood damage). In areas prone to hurricanes or tornados, the TEC shall be located away from exterior curtain walls to prevent wind and water damage.

The TEC shall be located a minimum of ≈3.7 m (12 ft) from any transformer, motors, X ray, induction heaters, arc welders, radio and radar systems, or other sources of electromagnetic interference.

Access to the TEC shall be restricted and controlled by ACS. A combination of the TEC and the EF shall be permitted.

Facility Requirements

Mechanical and electrical equipment or fixtures that are not directly related to the support of the TEC shall not be installed in, pass through, or enter the TEC.

All computer and networking equipment within the TEC shall be served by uninterruptible power supply. All circuits serving the TEC and the equipment within it shall be dedicated to serving the TEC.

Reliable cooling and heating shall be provided 24 hours a day, 365 days a year. Temperature and humidity in the TEC shall be controlled to an operating range of 18 to 24 degrees Celsius (ºC [64 to 75 degrees Fahrenheit (ºF)]) with 30 to 55 percent relative humidity.

Technology Distribution Room (TDR)

Technology distribution rooms (TDRs) provide a secure, flexible, and easily managed location for the structured cabling systems, network electronics, clinical systems, nurse call systems, and other technology and communication equipment throughout the building. TDRs house a variety of technology systems and system components (see Figure 19.1).

Typical systems and equipment located in TDRs include the following:

- Voice
- Data
- Overhead paging
- Closed-circuit security system
- Access control
- Audiovisual (AV)
- Distributed antenna system (DAS)
- Nurse call system

Number and Size

There shall be a minimum of one TDR on each floor of the facility. The quantity of TDRs shall be in accordance with the requirements of the standard being followed (e.g., TIA-568-C, TIA-569-C, TIA-1179, ISO/IEC 14763-2).

Under TIA/EIA-568-C, the maximum allowable horizontal cable distance is ≈90 m (295 ft) of installed cabling. The number of rooms per floor will be determined by this. The TDR shall be located on the same floor as the work area served.

All TDRs shall have minimum inside dimensions of ≈3.7 m by ≈4.3 m (12 ft by 14 ft).

Location and Access Requirements

The TDR shall be located in an accessible, nonsterile area on each floor. Access to the TDR shall be directly off a corridor and not through another space such as an electrical room or mechanical room.

Access to a TDR shall be restricted and controlled by ACS.

Facility Requirements

Mechanical and electrical equipment or fixtures not directly related to the support of the TDR shall not be installed in, pass through, or enter the TDR.

Each TDR shall be connected to the TEC to provide a building-wide network and communication system. All circuits serving the TDR and the equipment within it shall be dedicated to serving the TDR.

Reliable cooling and heating shall be provided 24 hours a day, 365 days a year. Temperature and humidity in the TDR shall be controlled to an operating range of 18 to 24 ºC (64 to 75 ºF) with 30 to 55 percent relative humidity.

Residential Cabling

Introduction

This chapter provides limited guidance on residential telecommunications cabling. Beyond living spaces with limited telecommunications needs, residences often include home offices that require high-speed Internet access, sophisticated automation, network backup systems, and bandwidth-intensive multimedia applications. All require a cabling system that performs well.

This chapter describes a residential cabling system within a home, a multi-dwelling unit (MDU), and a campus (e.g., gated community). This chapter addresses present and foreseeable future cabling needs. However, some equipment (e.g., electronics) may have special installation requirements that are not covered in this chapter, and manufacturer installation instructions may take precedence.

To ensure home connectivity, a choice between qualification and certification testing has been added in addition to the needed verification regimen. Qualification testing determines that certain network technologies will perform on the cabling system.

NOTE: Approximate metric measurements with corresponding imperial conversions within this chapter are denoted with the approximate symbol (≈) at the beginning of the metric measurements. Exact metric measurements with corresponding imperial conversions will not have this approximate symbol.

Residential Demarcation Points (DPs)

Residential cabling responsibilities have shifted from the access provider (AP) to end users—owners of homes, MDUs, and campuses.

For example, many APs provide access cabling up to the minimum point of presence (e.g., network interface device [NID]) on the exterior of a residence or to a point within an apartment or apartment complex.

Design for Flexibility

Residential construction typically has a defined number of units in a structure or campus (i.e., a home is one unit).

Because there is little probability of rearrangement once the cabling is placed in the walls, the system should be designed for:

- Anticipated long-term services.
- Maximum flexibility.
- Convenience of the tenant.

Design for Flexibility, continued

Where future telecommunications outlets or expansions of the home or building structure are anticipated, provide a means of extending cable. For example, if a new residence has a basement that could be used for a recreational area, place raceways of sufficient size from a distribution device (DD) to this area.

Initially, the information technology systems (ITS) distribution designer shall understand the tenant's immediate needs and desires and attempt to provide a cabling system that will be used to integrate with the tenant's future needs and systems. From this information, the ITS distribution designer can plan the telecommunications cabling system with one of the two grades of residential cabling.

Grades of Residential Telecommunications Cabling

There are two grades of residential premises telecommunications cabling. These two grades have been established based upon services that are expected to be supported within residential units and to assist in the selection of the cabling infrastructure (see Table 20.1):

- Grade 1 residential telecommunications cabling provides a generic cabling system that meets the minimum requirements for telecommunications services (e.g., telephone, satellite, community antenna TV [CATV], data services, multimedia telecommunications services). Grade 1 residential cabling provides one 4-pair balanced twisted-pair cable and associated connectors that meet or exceed the requirements for category 5e and one 75-ohm Series-6 coaxial cable. Installation of category 6 cable in place of category 5e cable is recommended.

  NOTE: The balanced twisted-pair cable and coaxial cable do not have to be terminated at the same location (e.g., wall telephone location). However, a minimum of one 4-pair balanced twisted-pair cable and one 75-ohm Series-6 coaxial cable shall be installed to all other outlets.

- Grade 2 residential telecommunications cabling provides a generic cabling system that meets the requirements for current and developing basic, advanced, and multimedia telecommunications services. Grade 2 residential cabling provides a minimum of two 4-pair balanced twisted-pair cables and associated connectors that meet or exceed the requirements for category 5e cabling and two 75-ohm Series-6 coaxial cables. Installation of category 6 cable in place of category 5e cable is recommended. Additionally, two-strand multimode optical fiber cable may be installed.

  NOTE: The balanced twisted-pair cable and coaxial cable do not have to be terminated at the same location (e.g., wall telephone location). However, a minimum of two 4-pair balanced twisted-pair cables and two 75-ohm Series-6 coaxial cables shall be installed to all other outlets.

The cabling associated with both grades of residential cabling is to be placed in a star topology. In addition, the length of each outlet cable is not to exceed ≈90 meters (m [295 feet (ft)]). This length allows an operational length of ≈100 m (328 ft), including an ≈10 m (33 ft) allowance for patch cords or jumper wire and equipment cords.

Telecommunications Outlets

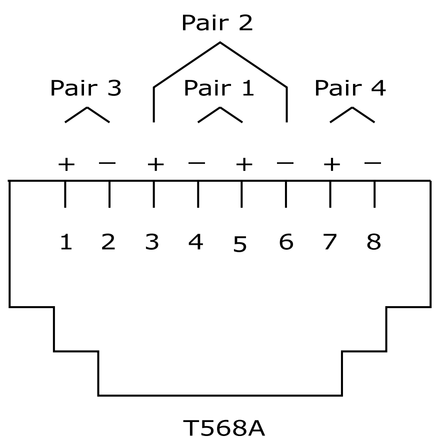
Install telecommunications outlets to their mounting hardware at the planned locations. Cover with a blank faceplate any mounting hardware containing cable runs intended for future telecommunications outlet locations.

Indoor telecommunications outlets contain a jack and cover assembly that is generally susceptible to moisture infiltration. Use indoor telecommunications outlets/connectors only in dry locations.

Outdoor telecommunications outlets contain a jack and cover assembly with a protective cap that is generally less susceptible to moisture infiltration. Use outdoor-type telecommunications outlets/connectors equipped with a protective cap in environments where moisture is a concern (e.g., exterior walls of buildings). Copper metallic telecommunications outlets/connectors used outside also should be of the type that are resistant to moisture.

For balanced twisted-pair cabling, terminate the connector-pin configurations as shown in Figure 20.11. Using the T568A configuration will accommodate many telecommunications services, including one-line and two-line telephone sets.

Figure 20.11
Telecommunications outlets/connectors



NOTE: The connector is viewed from the front opening with the tab down.

Premises Cabling System Testing

Telecommunications cabling (e.g., voice, data, video, security, audio, control) can be damaged during the construction phases of rough-in, drywall installation, and during the siding of the exterior. For these reasons, telecommunications cabling shall be acceptance tested. Acceptance testing includes visual examination of all cabling and verification of all cabling and qualification of copper cabling for data cabling or certification of copper or optical fiber cabling for data cabling.

Verification testing is generally performed in two steps:

- Prior to the installation of insulation and drywall
- During the trim-out stage of the cabling after painting

NOTE: Performing either a qualification test or certification of data cable generally negates the need for verification testing during the trim-out stage.

Verification testing of the cabling shall be performed to ensure proper end-to-end connectivity. Coaxial cable shall be verified to ensure continuity.

Twisted-pair cabling test shall include:

- Wire map.
- Length.
- Continuity to the remote end.
- Shorts between any two or more conductors.
- Crossed pairs.
- Reversed pairs.
- Split pairs.
- Any other miswiring.

Qualification of voice and data cabling is preferred over verification testing during the trim-out stage of cabling. Cable qualification tests the cabling to determine that certain network technologies (e.g., 1000BASE-T, 100BASE-T, Firewire™) will perform on the cabling system. Cable qualification shall be performed using network equipment installed on the cabling or by use of a qualification test instrument.

Certification may be used in lieu of verification testing or cable qualification testing of data cabling during the trim-out stage of cabling. Certification tests the cabling to all performance criteria of a category of cable. Certification testing, when implemented, should be done in the permanent link configuration.

The permanent link refers to the permanent part of the cabling installed (e.g., cable up to ≈90 m [295 ft] from the DD to the outlet and the connectors) without patch cords installed on each end of the cable.

