

Structured Cabling Systems

A Structured Cabling System (SCS) most simply stated is based on following a standard methodology defined by EIA/TIA 568 specifications when planning and installing network cabling for commercial buildings. The purpose of this standard is to specify a generic telecommunications cabling system for commercial buildings that will support a multi-product, multi-vendor environment. It also provides information that may be used for the design of telecommunications products for commercial enterprises.

By following these installation standards and using EIA/TIA compliant cabling products when the network doesn't work they can't blame you! The whole point of this standard that if followed the phone and networking equipment will work as designed. No surprised, no performance issues. Life is good!

The EIA/TIA-568 standard includes EIA/TIA-568-B.1 General Requirements, EIA/TIA-568-B.2 Copper Cabling Requirements, EIA/TIA-568-B.3 Fiber Cabling Requirements. There are other requirements for very specific issues related to these three but are not needed for this discussion. Similar ISO and IEC specifications exist such as ISO11801 but for our purposes they are similar enough to assume the requirements to be equal.

We will summarize each of the three standards separately, with the General Requirements containing the most relevant information. (And I do mean summarize. Between the three documents there are over 300 pages of extremely interesting information (note the sarcasm)). We will also discuss variations of this standard as it relates to the industrial environment.

EIA/TIA-568-B.1 General Requirements

We already talked about the purpose of this document. Requirements are defined for the following areas of the Telecommunications Cabling System Structure (see Figure 1)

1. Horizontal cabling
2. Backbone cabling
3. Work Area
4. Telecommunications Room
5. Equipment Room
6. Entrance Facilities

This structure is designed to support voice, data, text, video and image services.

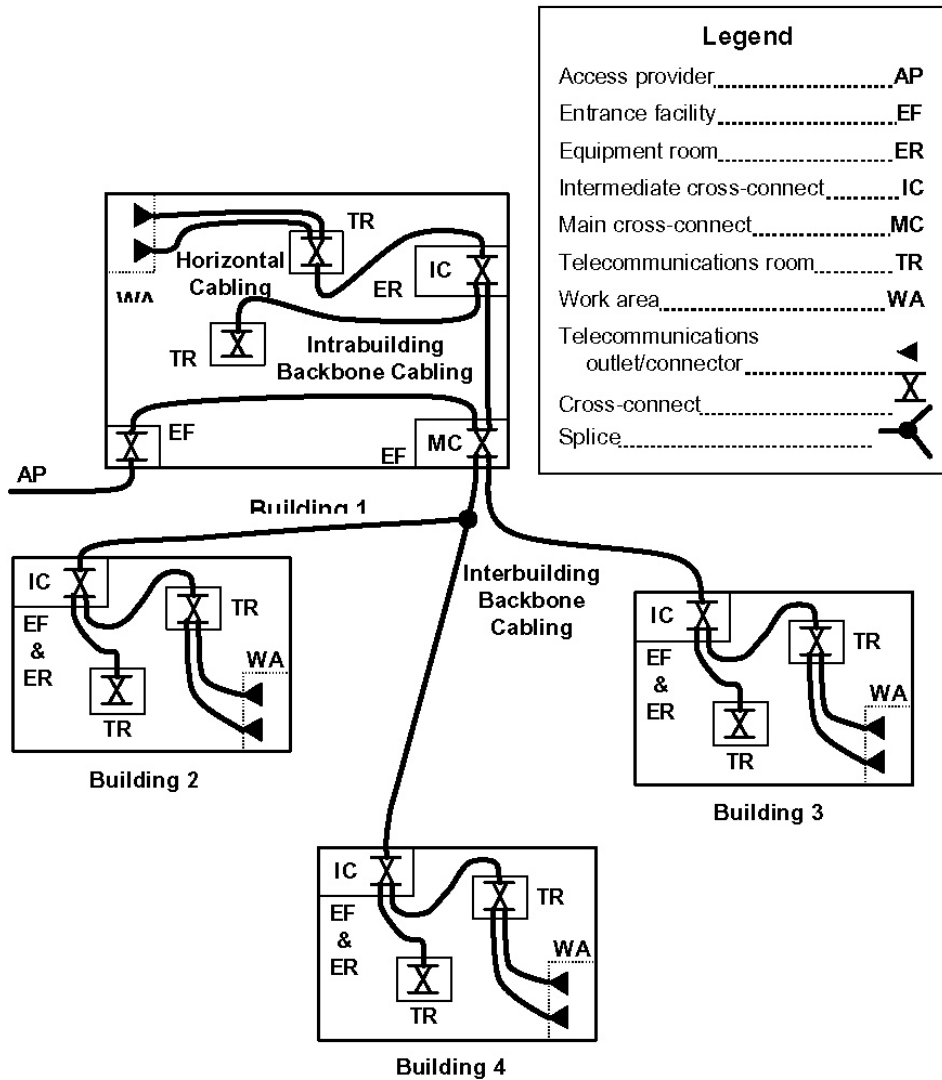


Figure 1

Horizontal Cabling

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

Note the term “horizontal” is used since typically the cable in this part of the cabling system runs horizontally in the building. Hmm. Makes sense!

The telecommunications room should be located on the same floor as the work area served. Note the word “should”. This means it is preferred but not required. When you see the word ‘shall’ it means it must be done or the SCS cops will teach you compliance! (Actually there are no SCS cops. We will talk about how to test a SCS later).

Figure 2 illustrates a typical horizontal cabling run. Note bridge taps and splices shall not (remember the word shall?) be installed as part of the copper horizontal cabling. Splitters either. No more than one transition point or consolidation point is allowed (We will talk about these later).

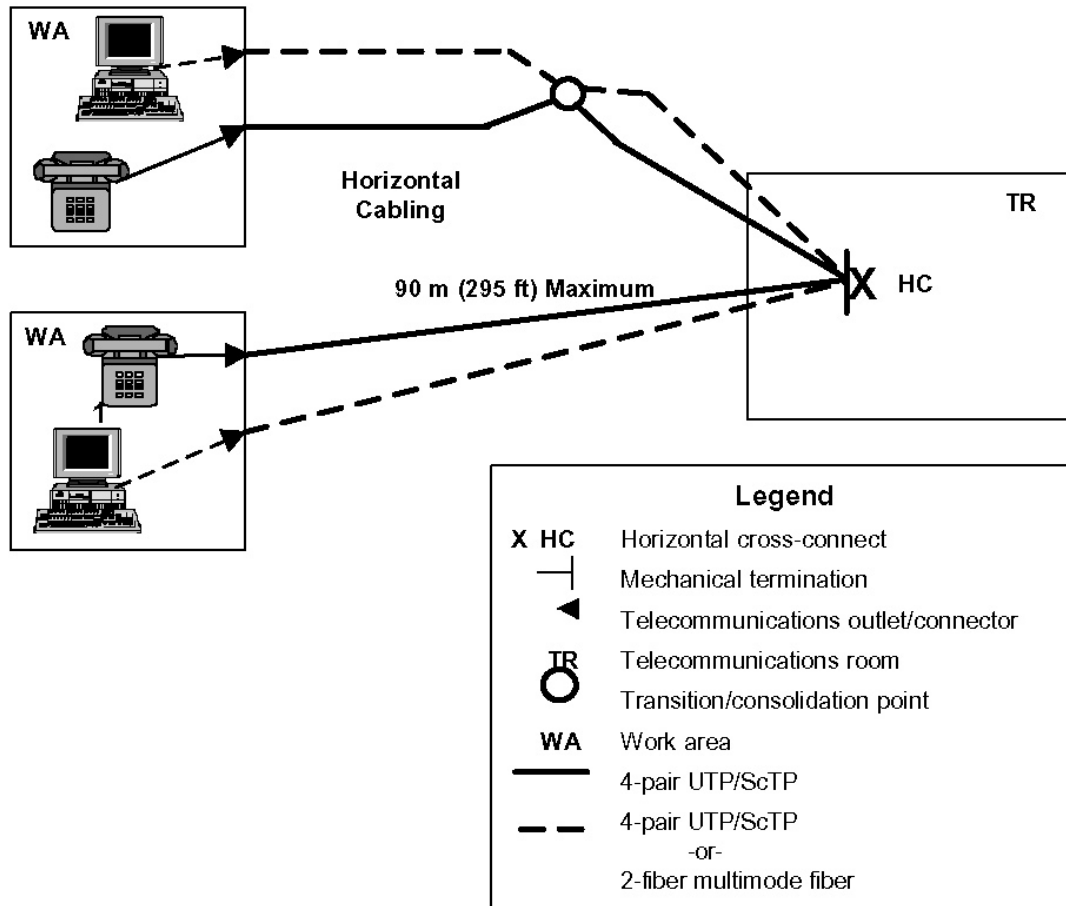


Figure 2

The maximum distance a horizontal run can be is 90 meters (295 feet). The longest a patch cord can be is 5 meters (16 feet). And the longest total length of patch cords on both ends can be 10 meters (32 feet).

The cables recognized by EIA/TIA include:

1. Four-pair 100ohm unshielded twisted pair (UTP) or screened twisted pair (ScTP) cables as defined in EIA/TIA-568-B.2
2. Two or more optical fiber multimode cable, either 62.5um or 50/125 um per EIA/TIA 568-B.3.

The standard also recommends that there “shall” be at least 2 connectors for each work area; one Category 3 or higher (we will get to categories soon) and the other number 1 or 2 above to support LAN services.

Backbone Cabling

The function of the backbone cabling is to provide interconnection between telecommunication rooms, equipment rooms, main terminal space and entrance facilities (did I forget the kitchen sink? Hey everything is being networked today.) It includes the backbone cables, intermediate and main cross-connects, mechanical terminations, and the patch cords or jumpers used for backbone to backbone cross-connection. It also includes cabling between buildings.

The backbone cabling shall use the hierarchical star topology as illustrated in Figure 3. From the horizontal cross-connect there shall be no more the one additional cross-connect to reach the main cross-connect.

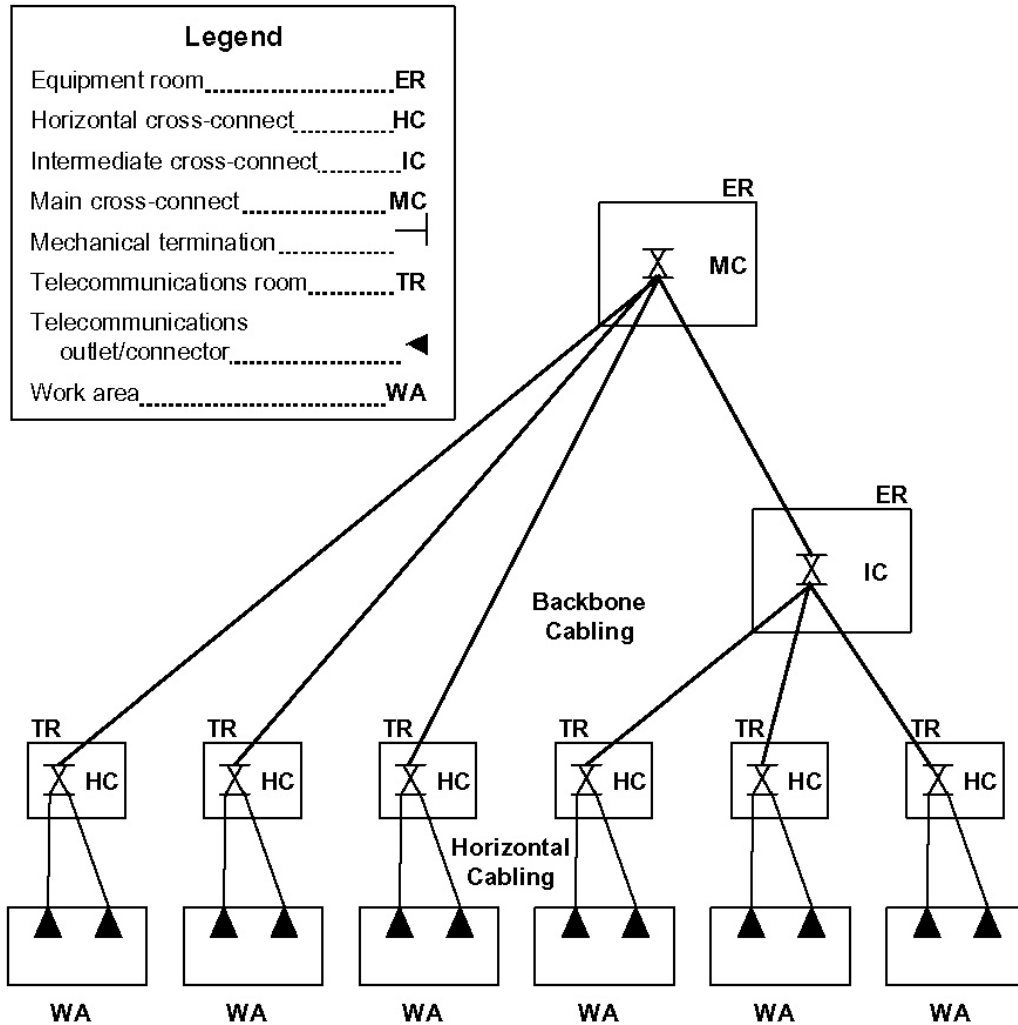
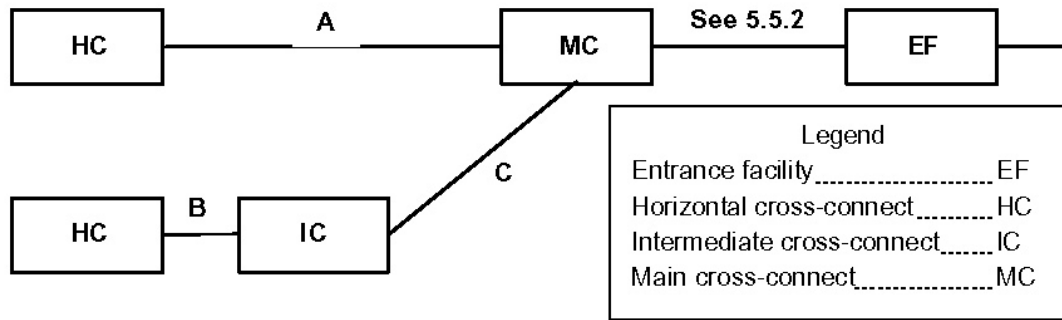


Figure 3

The cables used depend on the application Figure 4 list the maximum distance requirements for the various cable runs. Note that the distances listed for twisted pair cable is for supporting telephone use. To support higher network speeds the 90 meter UTP length still applies back to the main cross-connect.



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

Figure 4

In the main cross-connect, jumper or patch cord lengths should not (note “should” not “shall” so no beatings if you violate this one, though you could get blamed if something doesn’t work!) exceed 20 m (66 ft). Same for the intermediate cross-connect.

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

Work Area

The work area includes the telecommunications outlet/connector end of the horizontal cabling system to the work station equipment (i.e. PC, PLC, etc.).

The work area outlet is either in the form of a faceplate or a box. Its primary purpose is to hold the connector or modular jack. Per the standard each 4-pair cable shall be terminated in an eight-position modular jack per EIA/TIA-568-B.2 and IEC 60603-7.

There are two cabling schemes approved, T568A and T568B (see figure 5). The US Government only recognizes T568A, in case you wanted to know. The most common however is T568B as it was the standard scheme used by AT&T during their golden years as a monopoly.

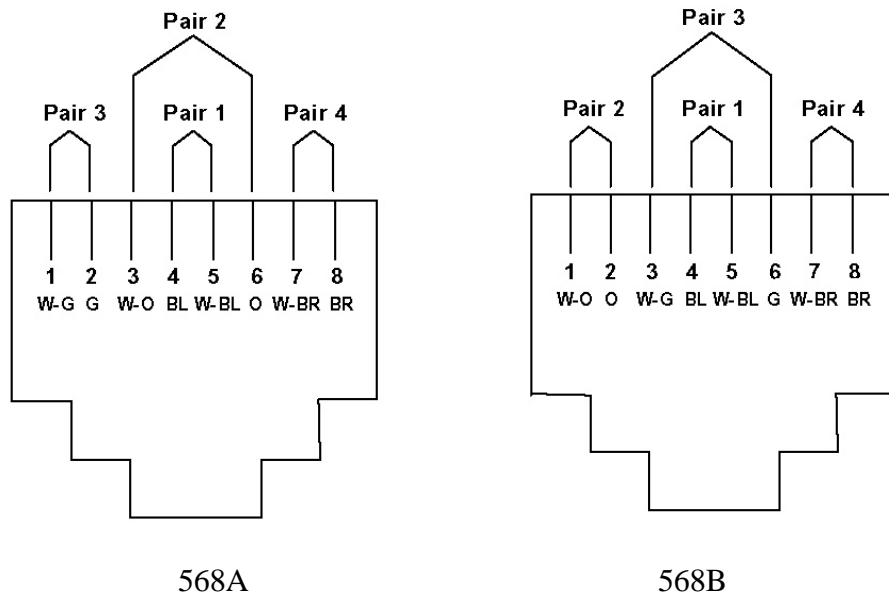


Figure 5

For fiber cabling these shall be terminated to a duplex optical fiber connector meeting the requirements of EIA/TIA-568-B.3. The SC connector is preferred by EIA/TIA but others can be used such as the ST and various small form factor connectors.

As already stated the maximum length allowed for the patch cord in the work area is 5 m (16 ft). (Just stating it again in case you weren't paying attention the first time.)

MUTOA (Multi-user telecommunications outlet assembly)

Remember that I just told you the maximum length allowed for the patch cord in the work area is 5 meters (hey you were paying attention)? Well there is an exception and it is when you use a MUTOA (I am not typing this out twice).

This was added to the standard to address the growing use of modular furniture in the commercial office. It provides a more flexible wiring means that facilitates changes easier. See figure 6. It also complicates things a bit, but as long as you follow the guidelines of Figure 7 you will stay compliant (and avoid the SCS cops, blame, etc.) It is limited to serving a maximum of 12 work areas. It shall also be located in a fully accessible permanent location, and not in ceilings.

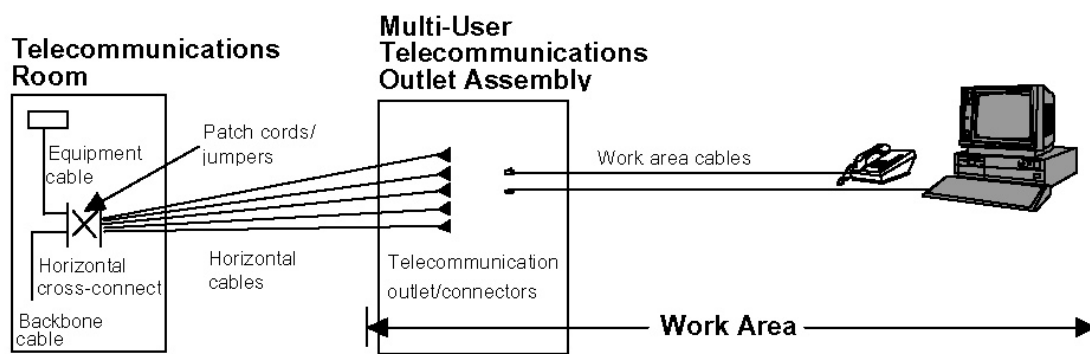


Figure 6

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

Figure 7

Consolidation Point

One other twist in horizontal cabling includes the Consolidation Point. It is an interconnection point within the horizontal cabling using the appropriate compliant connecting hardware, including the requirements of being rated for at least 200 cycles of connections. It also cannot be located within 15 m (49 ft) of telecommunications room as it can cause cabling performance degradation due to reflections.

The Consolidation Point may be useful when reconfiguration is frequent, but not so frequent as to require the flexibility of the MUTOA.

The Telecommunications Room

The primary function of a telecommunications room is the termination of horizontal and backbone cable to compatible connecting hardware. All connections between horizontal and backbone cables shall be cross-connections. Equipment cables/cords that extend a single port appearance may be connected through an interconnect.

So what is the difference between a cross-connect and an interconnect? Glad you asked! Figure 8 shows the difference. When terminating a small amount of cables (less than 100) an interconnect is fine. As the amount of connections grow the cross-connect provides better overall cable management.

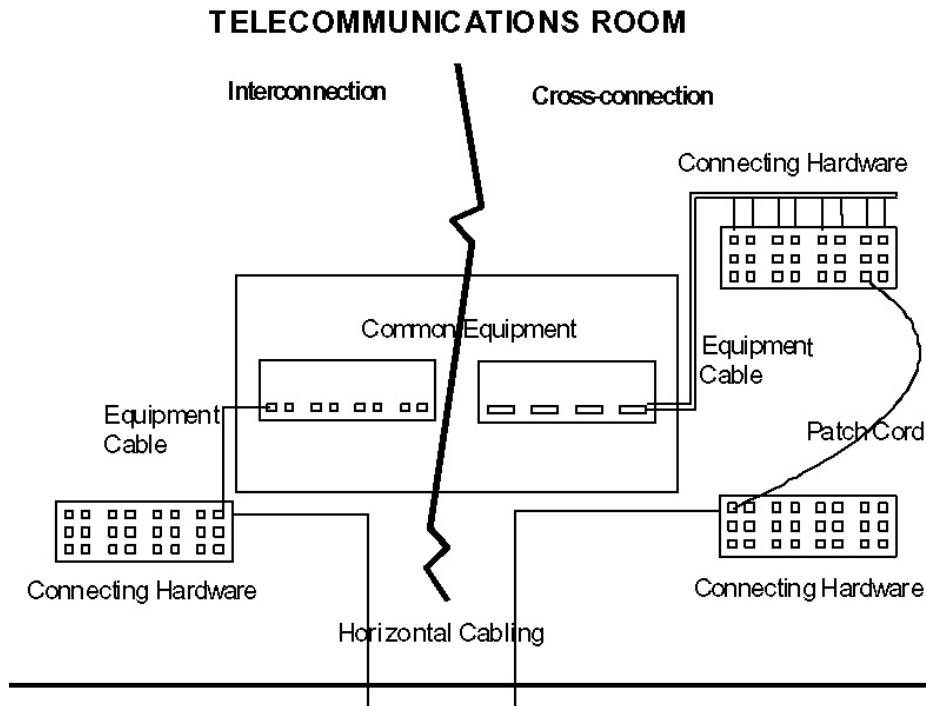


Figure 8

Equipment rooms are similar to Telecommunication Rooms except they typically house more variety or complex equipment.

Entrance Facility

The Entrance Facility consists of cables, connecting hardware, protection devices, and other equipment needed to connect the outside plant facilities to the premise cabling. It is beyond the scope of this paper to address this.

Cabling Installation Requirements

Just as important as choosing compliant connecting hardware and following the installation design guidelines of these standards is installation practices. Even the best cable and components improperly installed will not work, or at least not to its full potential.

Some of the most important installation requirements for UTP in order of importance include:

1. Cable pair twist shall be maintained to within 13 mm (0.5 in) from the point of termination. UTP gets a great deal of its performance attributes from the twist of the paired cables. It does not take much untwist to cause a measurable drop in performance. This is by far the most important factor for installation factors. Treat this as a must, do not deviate or whatever else you want to call it but do meet this recommendation.
2. While it may be obvious all cables shall be terminated with connecting hardware of the same category or higher. Terminating Category 5e cable on Cat 3 connectors will definitely hurt cabling performance. The same goes for the use of patch cords.

3. The minimum bend radius for horizontal UTP cable shall be four times the cable diameter, or in other words avoid sharp bends. To emphasize the importance of untwist the primary reason for this recommendation is that sharper bends tend to straighten out the twist in the pairs! There is no minimum bend radius for patch cables at this time.
4. Watch how hard you pull the cable. The maximum pulling tension of 4 pair 24 AWG UTP cable shall be 110 N (25lbf). Can you guess why this recommendation exists? That's right, be pulling too hard you untwist the pairs effecting performance!!
5. Use common sense when laying out the cable. For example do not run the horizontal cable right over fluorescent lights and wonder why you are picking up stray noise!

For fiber the following applies in order of priority:

1. Do not untwist Just seeing if you were paying attention. Fiber is the opposite. Twist it and it will break. The bend radius is the most important factor. Bend it too sharp and may not only degrade the signal but break and lose all the signal. The bend radius for 2 and 4 horizontal optical fiber cable shall not be less than 25 mm (1 in) under no load conditions. For backbone cable the bend radius shall not be less than 10 times the cable diameter unless otherwise recommended by the manufacture.
2. Proper connector termination is absolutely a must. The quality of the polish greatly determines the performance of the cabling system. There are many field terminable connectors that include a pre-polished stub that all you do is butt up the fiber cable to and terminate. It is not quite that easy but it is sure beats having to field polish the termination in generally less than ideal conditions.
3. And again use common sense keeping in mind the need to avoid sharp bends in the cable.

Testing

OK so you have bought all the right stuff and followed all the design recommendations and installed it perfectly, how do you test it? The exact test criteria is set out in great detail in the standards for both copper and fiber cabling and we will not go in great detail here on that. However you don't need to worry about these as testers exists that are certified to meet the standards and you just need to learn how to use them. They will tell you whether they meet the category of performance you are testing for, and depending on their features can help you isolate the problem.

There are two test used in the field to test a copper system, Channel test (Figure 9) and a Permanent Link test (Figure 10). The Channel test includes all components of the horizontal cabling system including the patch cords. This is the better test regarding actual performance. The Link test exists as there are many times cabling systems is installed before any office equipment is moved in or telecommunication room equipment is installed. This provides a test for the installer or contractor to verify the performance of the installation lacking the equipment patch cords.

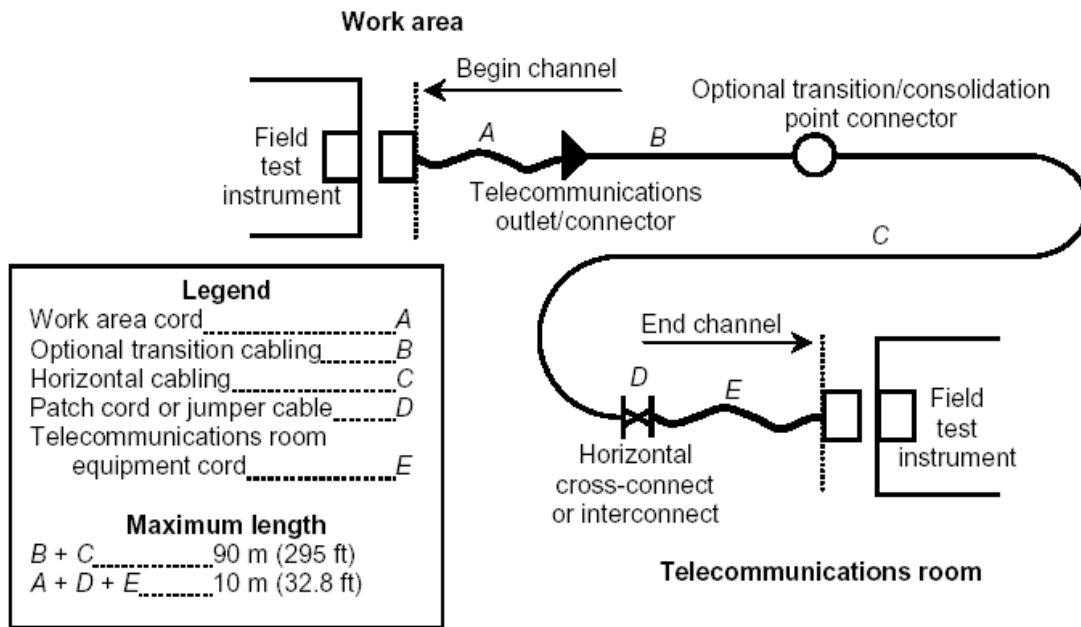


Figure 9

TIA/EIA-568-B.1

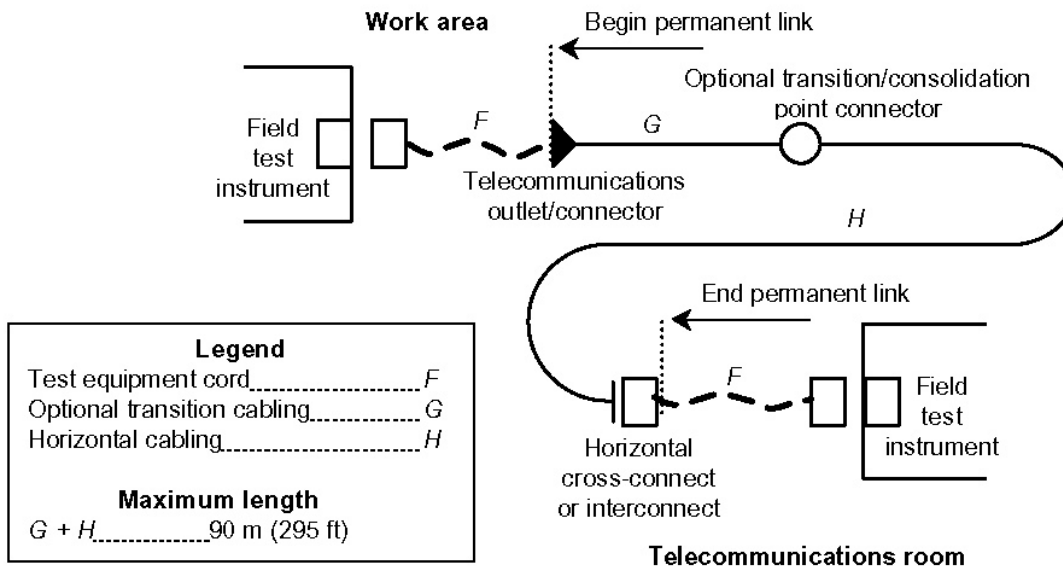


Figure 10

For fiber the test are just as straight forward providing you have a certified tester.

What are Categories for UTP cabling systems?

So what is Category 3, 5, 5e and 6? And why should I care? The recognized categories of twisted pair cable by EIA/TIA 568 are:

1. Category 3: This designation applies to 100 ohm cable whose transmission characteristics are specified up to 16 MHz.
2. Category 5e: This designation applies to 100 ohm cable whose transmission characteristics are specified up to 100 MHz
3. Category 6: This designation applies to 100 ohm cable whose transmission characteristics are specified up to 250 MHz

Cable, Patch Cords, and Connecting Hardware are all rated one of these categories. It is critical to note that rating of a cabling system is determined by its lowest rated component! If you have Cat 6 cable and connecting hardware everywhere but use a Cat 3 patch cord, you have a Cat 3 system. Don't do this.

For practical application Category 3 support 10BaseT Ethernet networks. Category 5e supports 10BaseT, 100BaseT and 1000BaseT (yes it really supports 1 gigabit LAN's over UTP). Category 6 supports everything Cat5e and will support 10GBaseT or 10Gigabit LAN's

Industrial Considerations

So what changes for the industrial environment related to the SCS? Actually very little. All the same standards apply including installation requirements and test requirements. And if you mount everything inside NEMA rated enclosures then nothing changes at all. However if you want to plug into the network from outside the enclosure there is a new connector style available called an Industrial RJ45. The specifications are being developed by EIA/TIA TR-42.9 committee and ODVA for Ethernet IP applications and are nearly complete.

This new connector interface, see Figure 11, contains at its core the 8 pin modular plug and connector specified in EIA/TIA 568. It is however surrounded with other mechanical connections to seal it against the environment with ratings such as IP67.



Figure 11

For an explanation of the IP rating system see Figure 12 below.

		IP Index	
1st Digit	Degree of Protection from Dust	2nd Digit	Degree of Protection from Water
0	No protection	0	No protection
1	Protection against solid foreign objects of 50 mm in diameter and greater	1	Protection against vertical water spray
2	Protection against solid foreign objects of 12 mm in diameter and greater	2	Protection against direct sprays of water up to 15 degrees from the vertical
3	Protection against solid foreign objects of 2.5 mm in diameter and greater	3	Protection against direct sprays of water up to 60 degrees from the vertical
4	Protection against solid foreign objects of 1.0 mm in diameter and greater	4	Protection from splashed water out from all directions
5	Protection against dust. Limited to ingress (no harmful deposits)	5	Protection from splashed water out of a nozzle from all directions
6	Total protection against dust.	6	Protection from temporary flooding
		7	Protection from temporary immersion
		8	Protection from water pressure - water tight

Figure 12

Conclusions

1. Structured Cabling in using an organized approach to the design and installation of the cabling based on EIA/TIA 568 specifications.
2. Critical issues to keep in mind include
 - a. Use EIA/TIA compliant cables, patch cords and connecting hardware
 - b. Do not exceed the 90 m horizontal cable length limits
 - c. Use the correct performance Category components to match the application. B&B recommends Cat 5e for UTP as it will support up to 1000 BaseT LAN's.
 - d. Do not untwist UTP, do not over bend Fiber
 - e. When using fiber look into the pre-terminated stub connectors on the market.
 - f. To know if you did it right there are testers designed just for this application for both copper cabling and fiber cabling.
 - g. If you want more details buy the EIA/TIA specifications and read them yourself.
3. There is an industrial variation of the modular connector interface with an IP67 rating for tough industrial environments. The standard is still pending so interoperability may be an issue if you mix and match components from multiple vendors.