WIRING STANDARD

INTRODUCTION

This standard defines a telecommunications wiring system for North Dakota State Agencies, offices or buildings that will support a multi-product environment. The purpose of this standard is to enable planning and installation of building wiring, regardless of the telecommunications products, be it voice and/or data, which subsequently will be installed.

This document addresses "telecommunications infrastructure cabling." This term encompasses all types of media used for voice, data and video communications. The media includes, but is not limited to, twisted-pair copper wire, coaxial cable, fiber optic cable and electrical grounding (earthing) cable. The term, Telecommunications, is defined to mean the transmission, reception and the switching of signals, such as electrical or optical, by wire, fiber, or electromagnetic means.

All telecommunications infrastructure work and materials will conform in every detail to the rules and requirements of the National Fire Protection Association, National Electrical Code, local Electrical Codes, any other applicable local or national codes, and present manufacturing standards. All materials will be listed by UL and will bear the UL label. If UL has no published standards for a particular item, other national independent testing standards will apply and such items will bear those labels. Where UL has an applicable system listing and label, the entire system will be so labeled.
The cabling system as described in this document is derived from recommendations made in recognized telecommunications industry standards:

- **ANSI/TIA/EIA - 568**, Commercial Building Telecommunications Cabling Standard.
- **ANSI/TIA/EIA – 569-A**, Commercial Building Standard for Telecommunications Pathways and Spaces.
- **ANSI/TIA/EIA – 570-A**, Residential Telecommunications Cabling Standard.
- **ANSI/TIA/EIA – 606-A-A**, Administration Standard for Telecommunications Infrastructure of Commercial Buildings.
- **ANSI/TIA/EIA – 607**, Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications.
- **ANSI/TIA/EIA – 729**, Screened, 100 ohm Twisted Pair Cabling
- **ANSI/ TIA/EIA – 758**, Customer-Owned Outside Plant Telecommunications Cabling Standard.
- **BICSI - TDMM**, Building Industries Consulting Services International, Telecommunications Distribution Methods Manual (TDMM)
- National Fire Protection Agency (**NFPA – 70**), National Electrical Code (**NEC**)
- IEEE 802.xx, Wireless Local Area Network (WLAN) Standards and Technologies

If this document and any of the documents listed above are in conflict, then the more stringent requirement will apply. All documents listed are believed to be the most current releases of the documents. The Contractor has the responsibility to determine and adhere to the most current local codes when developing the proposal for installation.

Proper adherence to these guidelines will reduce long-term building operation costs by providing a better infrastructure that is adaptable to change.

Telecommunications wiring defined by this standard is intended to have a useful life in excess of ten years.

DEFINITIONS, ACRONYMS AND ABBREVIATIONS

This section contains the definitions of terms, acronyms and abbreviations that have special technical meaning or that are unique to the technical content of this standard.

Definitions

Cable – An assembly of one or more conductors or optical fibers within an enveloping sheath, constructed to permit use of the conductors singly or in groups.

Cross-connect – A group of connection points, wall or rack mounted, used to mechanically terminate and administer building wiring.

Multimode Optical Fiber – An optical fiber that will allow many bound modes to propagate.

Patch Cord – A length of wire or optical fiber cable with connectors on each end to join communications circuits at a cross connect.

Single Mode Optical Fiber – An optical fiber that allows only one light mode to propagate.

Telecommunications – Any transmission, emission or reception of signs, signals, writings, images and sounds, or information of any nature by wire, radio, visual, optical or electromagnetic systems.

Telecommunication Outlet (Jack) – A connecting device located in a work area which horizontal wiring system cable terminates and which can receive mating connector.

Terminal – A word for a telecommunications closet.

Work Area – A building or office space where occupants interact with telecommunications equipment.

Acronyms and Abbreviations

EIA/TIA	Electronics Industries Association/ Telecommunications Industries Association
EMI	Electromagnetic Interference
IC	Intermediate Cross-connect
LAN	Local Area Network
MC	Main Cross-connect
TC	Telecommunications Closet

UTP	Unshielded twisted Pair
WAN	Wide Area Network

SPECIFICATIONS

HORIZONTAL WIRING

The horizontal wiring is the portion of the telecommunications wiring systems that extends from the area outlet to the telecommunications closet. This includes the termination at the outlet as well as the termination and cross connects at the closet. The term *horizontal* is used because typically the wire in this part of the wiring system runs horizontally along the floor(s) or ceiling(s) of a building.

The horizontal wiring shall be a star topology, meaning each work area outlet must be directly connected to a telecommunications closet. The maximum horizontal distance shall not exceed 300’ from the outlet to the closet as shown in Figure 1.1, an allowance of approximately 28’ was made for the patch cables in the wire closet and outlet end because the total length from the equipment in the telecommunications closet and the devise on the end cannot exceed 328’ total.

A minimum of two telecommunications outlets shall be provided for each individual work area. Both outlets shall be supported by a **4-pair Unshielded Twisted Pair (UTP) Category 6.** Each of these outlets may be used for either voice and/or data. Since both outlet ports are using the same type of cables, it’s just a simple matter of cross-connect in the telecommunications closet to either the voice switch or data switch.

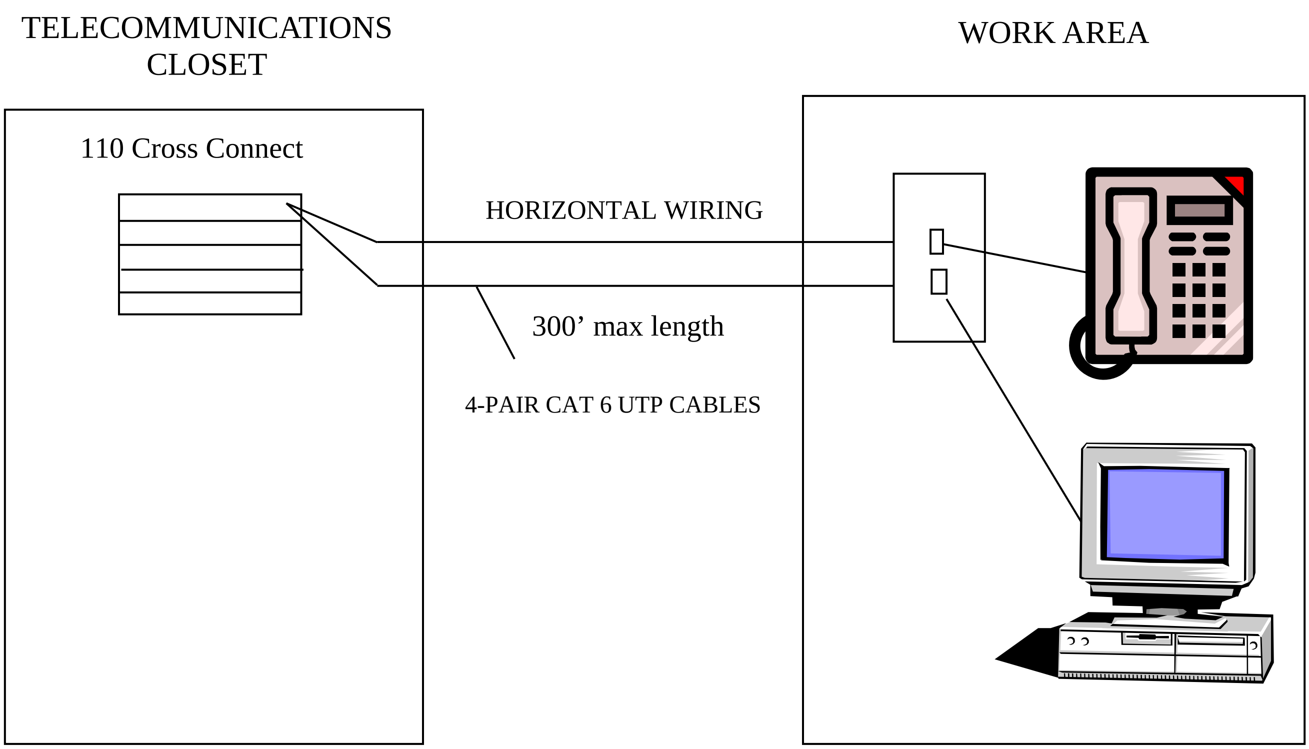


FIGURE 1.1 Typical Horizontal and Work Area Wiring

INSTALLATION

Category 6 wiring requires special installation practices. Pair twisting, for instance, is one of the critical physical characteristics of the cable that affects near-end cross talk performance. As a result, the **EIA/TIA Standard** requires that the pair twist be maintained to within one-half inch of the termination point on each end of the cable. This requirement is imposed to minimize untwisting of wire pairs and the separation of conductors within a pair.

Our standards call for special termination practices when terminating CAT 6 cable to ensure LAN speeds of up to 1 gigabit to ensure users get the most of their local area network.

When placing cables adhere to the following:

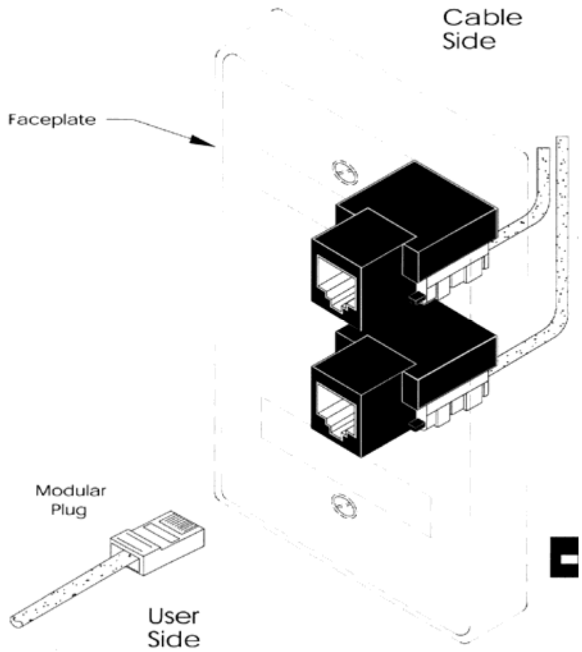
- Use a minimum bend radius of ten times the cable diameter equivalent to placing data wire around a 1" conduit.
- Follow building and fire codes penetrations made during routing of cable through firewalls. Firewalls must be sealed with fire stop materials. This stops the flow of smoke, flames, toxic fumes and etc.
- Avoid routing cables near Electro-magnetic interference noise sources, such as motors and power lines. Hangers are necessary to support the cable above fluorescent fixtures and other sources, which can induce noise on the cable.
- Use the same cable throughout. Do not mix cabling from different manufacturers.
- Avoid coiling cables. This can lead to degradation of its performance.
- Cable ties should be applied with just enough tension to hold the cables in place, but not tightly enough to squeeze the cables, also space the ties randomly.
- Cables must be supported a maximum of 5 feet intervals and cannot be attached to electrical conduit, heating or plumbing hardware or ceiling grid wires.

WORK AREA (OUTLET LOCATION)

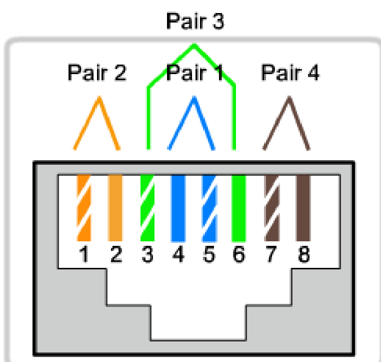
The work area components extend from the telecommunications outlet end of the horizontal wiring system to the station equipment. The station equipment can be any of a number of devices including telephones, fax machines and personal computers.

Work area wiring may vary in form depending on the application. A cord with identical connectors on both ends often is used. Our Standard calls for a CAT 6 cord when the application is a LAN Data device. When adaptations are needed they shall be external to the telecommunications outlet.

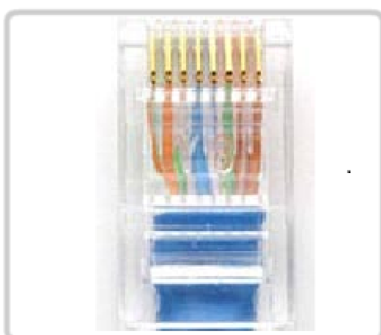
Each 4-pair cable shall be terminated in an eight-position CAT 6 Modular Jack as shown in the example below.



RJ-45 T568B Termination



T568B



T568B
(Top View)

FIGURE 1.2: Eight-Position Jack Pin/Pair Assignments (Designation T568B)

TELECOMMUNICATIONS CLOSET

A telecommunications closet is an area within a building set aside for the exclusive purpose of housing equipment associated with the telecommunications wiring system. Every building shall contain at least one telecommunications closet or equipment room. There is no upper limit on the number of telecommunications closets, which may be provided within the building.

The telecommunications closet shall contain the mechanical terminations for a portion of the horizontal wiring system and a portion for the backbone wiring system. In this usage, the telecommunications closet shall provide facilities (space, power, grounding, etc.) for the passive (cross-connect) or active devices or both used to interconnect the two systems.

All termination of station wiring at the telecommunications closet shall be terminated on **Cat 6 110-type hardware** with red designation labels. Backbone, riser or tie cables shall also be terminated on Cat 6 **110-type hardware** using green designation labels. The 110 blocks must be placed at normal working height and be at least 3 feet from powered transformers and power panels.

LABELING

Each telecommunications outlet shall have a label placed on the Faceplate or cover of jack, this is to identify the outlet for record keeping as well as for maps or floor plans. Each label will contain the xx-yyy-z identifier. The xx is the number of the telecommunications closet that the particular outlet is terminated in. The yyy is the number of the outlet. The z is the port number of the outlet.

Example: Term 1 jack 13 slot 1 = 01-013-1

TESTING

Contractors and installers will perform several tests in order to meet true CAT 6 performance for permanent link and channel compliance. The following tests must be completed and the results will be sent to ITD in an electronic format:

Return Loss - Return Loss test is a measure of the reflected energy caused by impedance variations in the cable and is especially important for applications that use simultaneous bi-directional transmission. Impedance mismatches cause reflections, which distort high speed data signals. A cable with good return loss will tend to have few signal reflections in the pair due to changes in impedance. A cable with poor return loss characteristics will lose signal strength or be highly distorted due to the signals being reflected.

Insertion Loss- The Insertion Loss, or also known as Attenuation, measured in dB, occurs when a device is inserted into a copper or fiber optic transmission line. In a telecommunications circuit void of any connections, each jack, plug or splice added will increase the attenuation of the circuit

Attenuation- Attenuation is the change in transmission signal strength between two points. The measure is in decibel(s), dB. For copper the measurement is usually taken at a certain frequency (or several), and for fiber at a specific wavelength. Attenuation is one of the major performance affecting factors of data cable, both copper and fiber. The signal at the distant end must be "loud" enough for the receiver to "hear" it. If it is not loud enough, an error may occur in the network causing retransmissions and impacting the network performance.

NEXT- NEXT (near-end crosstalk) shows the level of noise interference between each pair of signals at one end of the channel measured against a transmitted signal at that same end. A familiar example of cross talk in general is when you hear a second conversation on the telephone while you are talking. If there is too much crosstalk, it may interfere with transmitted signals. The noise is mainly generated where the connectors mate because the twisted pairs must run straight for a short distance.

PSNEXT- PSNEXT (power sum near-end crosstalk) shows the level of noise interference from all three of the other pairs summed together on each pair of signals at the near end to the transmitter. This is the noise level when all four pairs are used at the same time as with Gigabit Ethernet. Crosstalk can be minimized by retaining the cable pair twist configuration as much as possible when terminating the cable on the connecting hardware.

Attenuation to Crosstalk - Attenuation to Crosstalk (akin to ACR) shows the frequency range for which the signal is strong enough to be detected over the noise when using any two pairs. This is probably your most useful graph because this gives you a visual depiction of your frequency bandwidth, as you can see the point where your signal is no longer discernible from the noise.

Attenuation to PSNEXT - Attenuation to Power Sum Crosstalk (akin to PSACR) shows that the signal is strong enough to be detected over the noise when you are using all four pairs at one time. This is probably your most useful graph for because this gives you a visual depiction of your bandwidth for Gigabit Ethernet, as you can see the frequency at which your signal is no longer discernible from the noise.

FEXT - FEXT (far end crosstalk) is the measurement of crosstalk in dB at the opposite end of the cable from which the signal originated. FEXT is important, but with today's transmission schemes Power Sum ELFEXT is much more important.

ELFEXT - ELFEXT (equal level far-end crosstalk) shows the level of noise interference between each pair of signals at one end of the channel measured against a transmitted signal coming from the opposite end of the channel with the effects of attenuation removed. As with NEXT (near-end crosstalk) the noise is mainly generated where the connectors mate because the twisted pairs must run straight for a short distance. ELFEXT removes the impact of insertion loss on Far End Crosstalk.

PSELFEXT - PSELFEXT (power sum equal level crosstalk) is one of the mandatory tests under **ANSI/TIA/EIA 568-B.1 and B.2 Standard**. It shows the level of noise interference from all three of the other pairs summed together on each pair of signals at one end of the channel measured against a transmitted signal coming from the opposite end of the channel.

ACR - ACR (attenuation to crosstalk ratio) is the ratio of attenuation and crosstalk measured in dB at a given frequency. Sometimes known as Signal to noise ratio, this measurement is one of the defining tests for data cabling. If the result of this measurement is too low, then the receiving end will not hear the signal over the noise created on the line from other pairs. **EIA/TIA** specifies specific values for ACR in order to meet the various categories of cable. In Category 5e and 6 cables systems, Power Sum ACR is used, which is the cross talk calculation using 4 energized pairs.

PSACR - PSACR (power sum attenuation to crosstalk ratio) is similar to ACR except that Power Sum NEXT is used in the calculation instead of NEXT. PS-ACR is one of the main tests used when comparing various cables to determine which cable is better. PS-ACR is the difference between Attenuation and PSNEXT. The result is referred to as "head room". The more head room a cable or system has the more forgiving it will be with installation errors (apart from miss wiring).

All proposed fiber solutions should conform to the following specifications:
Acceptable DB loss:

- 0.25db/Km + 0.3db/splice +.5db/connector pair (bi-directional)

PMD (Polarization Mode Dispersion)

- 40 ps (pico seconds) for 2.5 Gig <2.0 PMD coefficient
- 10 ps for 10 Gig <0.5 PMD coefficient
- 2.5ps for 40 Gig <0.125 PMD coefficient

CD (Chromatic Dispersion)

- 16640 ps/nm for 2.5 Gig
- 1040 ps/nm for 10 Gig
- 65 ps/nm for 40 Gig

BACKBONE WIRING

The function of the backbone wiring is to provide interconnection between telecommunications closets, equipment rooms and entrance facilities in the telecommunications wiring system structure. Typically multi-pair cable and/or fiber optics cable are used as backbone cables.

The backbone wiring shall use the conventional hierarchical star topology where in each telecommunications closet is wired to a main cross-connect or an intermediate cross-connect then to a main cross-connect.

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

- Flexibility with respect to supported services;
- Required useful life of backbone wiring;
- Site size and user population

To determine the size of the backbone cable you need to estimate the number of users that could be assigned to work out of this particular closet. You then double that figure and round up to the nearest 100. Example: if 40 phones, faxes or modems are utilized, double it to 80 and round up to the nearest hundred. So in this case, a hundred pair cable should be sufficient.

FIBER OPTIC TECHNOLOGY

Fiber optic technology is now economically feasible and strategically beneficial for use in systems other than telephone trunking applications. Optical fiber in campus and premises communications system is becoming commonplace because optical fiber systems can handle very high data rates over long distances.

OPTICAL FIBER STANDARDS

For premises application (building and campuses) of distances less than 1.25 miles, our standard components are:

- Single-mode 9/125 um optical fiber
- Multi-mode 50/125 um optical fiber
- Multi-mode 62.5/125 um optical fiber
- LC or SC-compatible connectors

FIBER COUNT

Fiber Count is the number of fibers used in the cable plant. The fiber count selected for a communications network impacts both the current and future capabilities of the network.

In addition, to present and future communications requirements, a design must address redundancy, system administration and maintenance.

The decision regarding the number of optical fibers to install is largely dependent upon the:

- Intended end user application(s), both present and future
- Level of multiplexing
- Use of bridges/routers
- Physical topology of the network

Our standard calls for a minimum of 12 fibers to each building and/or telecommunications closet. Today's data communications systems generally employ two or four fibers between nodes to meet transmission requirements.

The most significant factor influencing the choice of fiber count for a data application is the level of electronics that will be used to combine like and/or dislike networks onto a common backbone (i.e., to what extent, if any, will bridges, routers or concentrators be used in the network).

Users often conclude that the most cost effective and manageable networks are those that require more fibers but fewer sophisticated (costly) bridges and routers.

When choosing a fiber count, consider the:

- Cost of additional fibers versus the cost of sophisticated end-electronics.
- Desirability of keeping networks separated versus the advantages of combining networks for security, performance and reliability.