1.0 Purpose

This document describes the minimum Metro requirements for all inside telecommunications wiring for new or remodeled buildings. This specification is to be used by contractors and/or Metro employees whenever premise or in-building telecommunications wiring is needed. If designed and installed properly, the final product will support most high-speed multi-product, multi-vendor environments.

2.0 Revision History

Date	Rev. No.	Change	Reference Section(s)
09/24/2007	1.0	New Process Drafted	Not Applicable
09/02/2009	1.1	Updating Standards	
9/10/2009	1.2	Add-Voice Patch Cord	6.4.7

3.0 Personnel Affected

All ITS personnel, including employees, contractors, and vendors.

4.0 Definitions

4.1 ITS.
Metro Nashville Government Information Technology Services

4.2 ITS Personnel.
All full time, part time and contract employees working under direction of the ITS department.

5.0 Responsibilities

5.1 The ITS Director is responsible for ensuring compliance to this defined policy.

5.2 All ITS department managers are responsible for ensuring that existing employees, new employees, contract employees and vendor representatives comply with this policy.

5.3 All ITS employees, contract employees and vendor representatives are responsible for compliance with this policy.

5.4 All ITS employees and contract employees are responsible for reporting known violations of this policy to their management.

6.0 Procedures

6.1 Overview

Items not specifically covered herein will use the appropriate reference documents in Section 10. It is very important that those who use this specification make sure they have the latest reference material. It should be noted that on occasion, equipment manufacturers and/or system providers might require wiring standards and components beyond those covered herein. When this situation occurs, the cabling plant will be upgraded where necessary, while still maintaining the parameters of this specification. Telecommunication types covered include: telephony, data, and video/RF communications.

This specification will typically support commercial buildings up to 10 million square feet of office space and up to 50,000 individual users. Telecommunications cabling systems specified herein are intended to have a useful life in excess of five years. The specification does not cover active electronic devices such as: switches, hubs, routers, computers, telephones, etc. but rather the wiring to interconnect these devices within a commercial office building.

This specification is based on the latest ANSI/TIA/EIA standards, BICSI practices, and the National Electric Code (NEC). These documents are continuously being revised. The system designer, material suppliers, and installation personal must follow the latest reference materials at time of implementation.

System design activities must be performed by BICSI trained RCDD (Registered Communication Distribution Designer) personnel. All installation activities must be performed by the appropriate BICSI trained Installation Level personnel, and finally that all testing and installation supervision activities must be performed by BICSI trained Technician Level personnel. System testing and acceptance are significant requirements of any building wiring system.

During the installation and testing process, initial documentation of system records is very important. This is a continuous system management process. A well-designed telecommunications wiring system will become a nightmare unless all moves, adds, and changes are properly documented as the system evolves.

If data applications anticipated will require transmission speeds beyond gigabit/s rates, the user should consider installing category 6 cabling or optical fiber to future proof and/or give additional headroom for category 5e systems.

This specification does not address ancillary systems, such as: Public Address, Building Automation, HVAC control, Intercom, and Wireless systems.

All new cable installations must use components manufactured by CommScope. Additions to existing cable plants must use components to the extent possible. Unused ports on existing patch panels and face plates made by other manufacturers may be used in existing cable plants. Wire management and rack components are required.

6.2 Horizontal Cabling

6.2.1 General

Horizontal cabling is that portion of the cabling that extends from the WA (work area) outlet to the HC (horizontal cross-connect) in the TR (telecommunications room).

6.2.2 Topology

Horizontal cabling must be installed in a star topology. Each cable shall be a homerun without splices. Application-specific electrical components (such as impedance matching devices) shall not be installed as part of the horizontal cabling. These components will be added externally to the TO (telecommunications outlet). This facilitates testing and use of the cabling for varied network requirements. Horizontal cabling shall contain no more than one TP (transition point) or CP (consolidation point) between the HC and TO. Taps and/or splitters are not allowed.

6.2.3 Horizontal Distances

The horizontal distance is the cable length from the mechanical termination at the HC to the TO. The maximum allowed distance is 90 m (295 ft) independent of media type (UTP, coax, fiber, etc.). This allows 10 m (32 ft) for patch cords and equipment cables. If MUTOA (multi-user telecommunications outlet assembly) is used, the maximum distance will be reduced in accordance to paragraph 6.4.1.4 of TIA/EIA-568-B.1.

6.2.4 Recognized Cables

Two types of cables are acceptable for new installations, either or both can be used as required by the system applications:

Fiber

(a) 4-pair 100-ohm UTP (or ScTP as required for specific electrically noisy environments)
(b) 2-fiber 50/125 um MMF

(c) 75-ohm RG6 (CATV only)

Two types of cables are acceptable for new installations, either or both can be used as required by the system applications:

(d) 4-pair 100-ohm UTP (or ScTP as required for specific electrically noisy environments)
(e) 2-fiber 50/125 um (or alternately 62.5/125 um) MMF

Cables may be individual cables or in bundled or hybrid formats.

Do **NOT** use 2-pair 150-ohm STP-A cable (or 50-ohm IEEE 802.3 10BASE2 coax) on new installations. Two UTP/ScTP cables shall be configured for each WA location, unless data at the location is designed for optical fiber, then a combination of one 4-pair UTP/ScTP and two MMF will be used. Although the TIA/EIA-568-B.1 standard allows category 3 cable for voice applications, Metro requires that all new or modified systems will have a minimum of 4-pair category 5e cables for both voice and data, unless the WA location is designed for optical fiber. This facilitates testing and allows for future flexibility. 75-ohm Series 6 coaxial cable can be used if required by the system application in addition to the copper/MMF cables. Do NOT use traditional multipair (greater than 4-pair) cables, even if they are rated as category 5e, as their performance especially in mixed systems cannot be predicted.

Copper conductors shall be solid 24 AWG meeting all requirements of TIA/EIA-568-B.2.

If using ScTP cables the shield shall be bonded through a conducting path to the TGB (telecommunications grounding busbar) in the TR. When using ScTP cables, the entire system must support that conducting path end-to-end. Acceptable voltage measurement between the WA TO shield and the ground wire at the electrical outlet supplying power to the workstation is less than 1.0 Vrms.

6.2.5 Color Coding

6.2.5.1 Pair Colors

UTP/ScTP cable pairs will be identified with the following colors:

Pair 1 - White-Blue and Blue
Pair 2 - White-Orange and Orange
Pair 3 - White-Green and Green
Pair 4 - White-Brown and Brown

6.2.5.2 Jacket Colors

Use the following overall jacket colors to identify cable use:

Blue – Cat5e – Following 568B standards
Purple – Cat6
Black - RF/Video-RG6
Orange – Multi-mode Optical Fiber
Yellow – Single-mode Optical Fiber

6.3 **Backbone Cabling**

6.3.1 General

The function of the backbone cabling is to provide interconnection between the HC and IC (intermediate cross-connects)/MC (main cross-connects) located in the ER (equipment room) or at the EF (entrance facility).

To estimate the number of copper pairs (or optical fibers) needed in each backbone segment, calculate the maximum number of users and simultaneous applications projected (the horizontal cables) and multiple by 150%. Always use worst-case scenarios.

If the maximum projected number of voice users to a HC location is 10, then there would be 40 UTP pairs x 150% or a minimum of 60 pairs in the backbone cabling for voice. Data backbone cabling would be calculated in the same manner.

Splices are allowed in backbone cabling if designed in and/or approved by Metro IT. Building to building must have lightening protection and grounding on both ends.

6.3.2 Topology

The backbone cabling shall use hierarchical star topology wherein each HC in a TR is either cabled directly to a MC or to an IC then a MC. There shall be no more than two levels of cross-connects in the backbone cabling.

Non-star configurations (such as ring, bus, or tree) will be accommodated through appropriate interconnections, electronics, or adapters in the TR, not within the backbone cabling.

6.3.3 Recognized Cables

Three types of cables are acceptable for new installations that can be used individually or in combination, as the design requires:

(a) 100-ohm UTP
(b) 50/125 um MMF
(c) 9 um SMF

Do **NOT** use other types of cables unless directed by Metro ITS for special applications and then only in addition to the listed cable types above. To maintain system performance of a UTP backbone, non-multi-pair category 5e cable should be used. Copper conductors shall be solid 24 AWG meeting all requirements of TIA/EIA-568-B.2.

6.3.4 Backbone Cabling Distances

In large installations the MC location should be as centrally located as possible to minimize cabling distances.

The total distance is part of the maximum horizontal distance of 90 m (295 ft) independent of media type (UTP, coax, fiber, etc.) for proper performance. Those portions of the backbone used solely for voice transmissions may have a maximum distance of 800 m (2624 ft) with an IC to HC maximum distance of 300 m (984 ft) regardless of media used. Maximum distance for optical fiber backbones is dependent on: application, wavelength of light, fiber type (single-mode or multimode and core size), and link budget. Refer to TIA/EIA-568-B.2 Annex E for guidelines. In general, MMF is limited to 2000 m (6560 ft) and SMF is limited to 3000 m (9840 ft).

6.4 Work Area

6.4.1 General

Work area components include the TO and equipment cables at the user's work station. They are not limited to numbers or types of devices (telephones, modems, faxes, computers, data terminals, etc.).

6.4.2 Telecommunications Outlet/Connector

6.4.2.1 100-ohm Balanced Twisted-Pair Connectors

Each 4-pair cable shall be terminated in an 8-position modular category 5e jack of either UTP or ScTP type to match the installed cable type (angled is preferred, flat or straight is acceptable). Pin/pair assignments shall follow the T568B convention for new work as listed below:

T568B2

Pin #	Wire Color	Pair #
1	White-Orange	2T
2	Orange	2R
3	White-Green	3T
4	Blue	1R
5	White-Blue	1T
6	Green	3R
7	White-Brown	4T
8	Brown	4R

6.4.3 Optical Fiber Connectors

Horizontal optical fibers to the work area will terminate into a SFF (small form factor) duplex outlet/connector of LC design (EIA/TIA-604-10). While there are many non-compatible SFF connector styles used by the telecommunications industry, LC is widely used and very compact. If previous applications have used duplex 568SC or simplex ST/SC connectors, they shall be accommodated by factory-made LC jumper/adapters with the appropriate connector style on one end.

6.4.4 Faceplates

Use of faceplates is to accommodate the T568B and MT-RJ connectors terminating UTP/ScTP copper and optical fiber cables. The individual components and work area system must be manufactured and compliant with CommScope or approved by written Metro ITS policy.

Each single gang faceplate must be, at minimum, a quad modular connector style. Any unused positions will be covered by blank inserts.

6.4.5 Equipment Cords

Equipment cords are used to connect the TO to the user equipment. Maximum length is 5 m (16 ft). Where communication devices are located farther away, it will be required to move the TO closer to the user equipment. Except for temporary emergency repairs only factory terminated and tested modular cords are allowed. All equipment cords will use UTP/ScTP 24 AWG stranded wire.

6.4.6 Data Patch Cords

In addition to the specifications under Section 4.4, all data equipment cords will be 4-pair UTP/ScTP category 5e cords terminated with T568B connectors. Data equipment cords will be color coded blue (non-booted).

6.4.7 Voice Patch Cords

In addition to the specifications under Section 4.4, all data equipment cords will be 4-pair UTP/ScTP category 5e cords terminated with T568B connectors. Data equipment cords will be color coded blue (non-booted).

6.4.8 MUTOA (Multi-User Telecommunications Outlet Assembly)

Open office spaces (modular furniture) require special considerations. The distribution point is called a MUTOA (multi-user telecommunications outlet assembly). It is fed from the HC with horizontal cables to central locations within a furniture cluster. Work area cables are then routed through furniture pathways up to a maximum of twelve (12) work areas. Maximum lengths of copper cabling will be limited by the following formula:

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

Where: C = Maximum combined length (m) of the work area cable, equipment cable, and patch cord.

H = Length (m) of the horizontal cable

D = De-rating factor for the patch cord type (0.2 for 24 AWG UTP/ScTP)

The following table shows maximum lengths allowed in open space applications:

Length of Horizontal Cable	Maximum Length of Work Area	Maximum Combined Length of Work Area Cables, Patch Cords, and

H m (ft)	Cable W m (ft)	Equipment Cable C M (ft)
90 (295)	5 (16)	10 (33)
85 (279)	9 (30)	14 (46)
80 (262)	13 (44)	18 (59)
75 (246)	17 (57)	22 (72)
70 (230)	22 (72)	27 (89)

If electrical and cat5e cables share a power pole in a modular environment they must have a separate channel.

6.4.9 Optical Fiber Links

For optical fiber cables, extending the lengths of work area cables to reach a MUTOA does not require reduction of the total channel length allowance of 100 m (328 ft).

6.5 Pathways and Spaces

6.5.1 General

This section covers horizontal pathways, intra-building pathways, TR (telecommunications rooms), ER (equipment rooms), EF (entrance facility), and fire stopping. The telecommunications industry has changed the terminology from TC (telecommunications closet) to TR (telecommunications room) to better reflect the real needs of this component.

The primary function of the TR is termination and cross-connection of horizontal and backbone cables. The primary function of the EF is demarcation from service providers and customer premises cabling. The primary function of the ER is a controlled environment to house telecommunications equipment. These may be separate rooms/facilities or combined together.

6.5.2 Horizontal and Backbone Pathways

The primary means of supporting or protecting cable in horizontal pathways is either conduit, trays, in ceiling or any combination of these and may include pull boxes.

Conduit should be avoided because of its inflexibility except for through floor sleeves, ground wire protection, in-wall stub-ups for outlets, or as required by local codes. Maximum length of conduit shall be 30 m (100 ft) between pull boxes. No section of conduit shall have more than 180 degrees of bend between pull boxes. The inside bend of conduit shall be at least six (6) times its internal diameter. Any conduit run can serve no more than three (3) outlets. Conduit sizing guidelines can be found in ANSI/TIA/EIA-569-A Table 4.4-1. Pull string or rope with distance marking shall be placed in all conduits before and after cables are pulled. Pull boxes shall not be used for splicing or terminating cables. Pull boxes shall be readily accessible. Pull box length for straight pulls shall be at least eight (8) times the trade-size diameter of the largest conduit. Pull box size for angled pulls shall be six (6) times the largest conduit plus the sum of all other conduits entering that wall. Pull box sizing guidelines can be found in ANSI/TIA/EIA-569-A Table 5.2-2.

Cable trays are preferred over conduits. They can be of any style including non-metallic with plenum rating. A minimum of 300 mm (12 in) of headroom shall be provided and maintained above the cable tray. Conduits are preferred over cable trays for fiber optic cable used in horizontal pathways. Conduits should contain only fiber optic cable and not be intermixed with copper cables.

Ceiling pathways shall follow NEC and local codes. Telecommunications cables shall only be installed in ceiling spaces where ceiling tiles are removable or lay-in types and shall not be laid directly on ceiling tiles or rails. Where non-conduit or non-tray support systems are used in ceiling spaces the cables shall be supported on 1220-1525 mm (48-60 in) centers and must be of a category 5e type. The T-bar rail of a suspended ceiling may be used to mount appropriate cable fasteners up to a cable weight of 0.7 kg/m (0.45 lb/ft). All pathway methods shall enter the TR a distance of 25-75 mm (1-3 in) before any bends and shall be above the 2.4 m (8 ft) level.

Perimeter pathways may be used of either metallic or plastic materials as long as they are designed for category 5e and if used with power have appropriate divider to separate power and communications.

Under carpet pathways and cabling system are not approved. If installation conditions require it and approved by Metro, the selected system must have a category 5e rating.

Where inter-floor sleeves are required for communications cables there shall be one (1) sleeve for every 5000 m^2 (50,000 ft^2) of usable floor space served by the backbone of 103 (4) trade size, plus two (2) spares.

Specific application of specialty types of pathways and spaces are covered in addendums to TIA/EIA-569-A covering surface raceways, furniture, access floors, poke-thru fittings, and in-floor systems. Size of pathways will be determined by quantity, size, and bend radius of cables to meet category 5e requirements with allowance for growth of at least 50%. Horizontal pathways may not be installed in elevator shafts or wet locations as defined by NEC Article 100 such as on concrete slabs.

6.5.3 Telecommunications Room

A telecommunications room TR shall be located on each floor as close as practical to the center of the floor space and preferably in the core area.

Additional TRs shall be provided when the floor area being served exceeds 1000 m^2 (10,000 ft^2) or the horizontal distribution distance to the WA exceeds 90 m (295 ft). The TR shall be dedicated to the telecommunications function and related support facilities and not shared with electrical or HVAC installations nor shall water pipes, ductwork, pneumatic tubing, etc. pass through the TR. Multiple TRs on a floor shall be interconnected by a minimum of one (1) conduit 78 (3) trade size or equivalent pathway. Based on one (1) WA per 10 m^2 (100 ft^2), the minimum acceptable TR dimensions are as follows:

Serving Area		TR Size	
m^2	ft^2	mm	Ft
1000	10,000	3000 x 3400	10 x 11
800	8,000	3000 x 2800	10 x 9
500	5,000	3000 x 2200	10 x 7

The TR shall have a minimum floor loading of 2.4 kPa (50 lbf/ft2) or more if unusually heavy equipment is anticipated. Ceiling to floor height should be 3000 mm (10 ft) to allow for cable trays above racks and terminal block mounting plywood. A minimum of two (2) walls should be covered with rigidly fixed 20 mm (3/4 in) A-C void-free, unpainted, fire-rated plywood,3000 mm (10 ft) high. Lighting shall be a minimum of 500 lx (50 foot candles) measured 1 m (3 ft) above the finished floor, mounted 2600 mm (8.5 ft) minimum above finished floor. Lighting fixtures should not be powered from the same electrical distribution panel as the telecommunications equipment in the TR. Dimmer switches shall not be used. For maximum flexibility, false ceiling shall not be provided. The door shall be a minimum of 910 mm (36 in) wide and 2000 mm (80 in) high, without doorsill, hinged to open outward (codes permitting) or be removable, and fitted with a lock. Floors, walls, and ceilings shall be treated with a light color to eliminate dust. A minimum of two (2) dedicated 120 VAC 20 A non-switched AC duplex electrical outlet receptacles, each on a separate branch circuit, shall be provided for equipment. In addition, convenience duplex outlets shall be placed at 1.8 m (6 ft) intervals around the perimeter walls, at a height determined by Metro codes department. If standby power is available, automatic switchover power should be provided. It is desirable that a dedicated power panel be installed within the TR. Fire protection for the TR shall be provide as per local codes. If sprinkler heads are required by local codes, they shall be provided with wire cages to prevent accidental operation. HVAC shall be included to maintain temperature the same as the adjacent office area. Provisioning for continuous HVAC 24x7 shall be included. A positive pressure shall be maintained with a minimum on one (1) air change per hour. The HVAC system shall be connected to standby power if available.
Additionally, if a UPS or generator is required, Metro ITS will provide electrically specification during project design.

6.5.4 Equipment Room

The equipment room ER is a centralized space for telecommunications equipment such as PBX, computer servers and video switches. As stated previously the ER and TR can be the same room. Avoid areas that limit expansion such as elevators, core, outside walls, or other fixed building walls. The ER shall be accessible for delivery of large equipment. Floor loading shall be sufficient to bear both the distributed and concentrated load of installed equipment. The floor shall be designed for a minimum distributed load rating of at least 4.8 kPa (100 lbf/ft^2) and a minimum concentrated load rating of at least 8.8 kN (2,000 lbf) or more if unusually heavy equipment is anticipated. The ER shall not be located below water level and be free of water supply or drain pipes unless needed to support the installed equipment. A floor drain shall be provided within the ER if risk of water ingress exists. The ER shall be located with ready access to the main HVAC delivery system. The ER shall be located away from sources of EMI such as electrical transformers, motors, x-ray equipment, transmitters, and induction sealing devices. The ER shall be sized to accommodate known and future equipment requirements. If unknown, provide at least 0.07 m^2 (0.75 ft^2) of ER space for every 10 m^2 (100 ft^2) of work area space. As a minimum 14 m^2 (150 ft^2) shall be provided. Environmental control equipment, such as power distribution or conditioner systems, and UPS up to 100 kVA shall be permitted in the ER. The ER shall be dedicated to the telecommunications function and related support facilities and not shared with electrical or HVAC installations nor shall water pipes, ductwork, pneumatic tubing, etc. pass through the ER. Doors providing access to other areas of the building through the ER should be avoided to limit access to authorized personnel only. Minimum clear height in the ER shall be 2440 m (8 ft) without obstructions. If contaminants are present in greater concentrations as indicated in ANSI/TIA/EIA-569-A Table 8.2-2, the ER shall be provided with vapor barriers, positive room pressure, or absolute filters. If sprinklers are required by local code, the heads shall be provided with wire cages to prevent accidental operation and drainage troughs shall be placed under sprinkler pipes to prevent leakage onto equipment. Consideration should be given to the installation of alternate fire-suppression systems. HVAC shall be provided 24x7 by a standalone unit for the ER if the building cannot supply the need. If available the HVAC should be connected to a standby power supply if available. The temperature and humidity shall be controlled to provide continuous operating ranges of 18 to 24 degrees Celsius (64 to 75 degrees Fahrenheit) with 30% to 55% relative humidity. Ambient temperature and humidity shall be measured at a distance of 1.5 m (5 ft) above the floor, after equipment is operational. There should be a positive pressure differential with respect to surrounding areas. If batteries are used for backup, adequate ventilation shall be provided. Floors, walls, and ceiling shall be sealed in a light color to reduce dust. Floor materials having antistatic properties shall be selected. Lighting shall be a minimum of 500 lx (50 foot candles), measured at 1m (3 ft) above the finished floor, controlled by one or more switches located near entrance doors. Lighting fixtures should not be powered from the same electrical distribution panel as telecommunications equipment. Dimmers shall not be used. Power shall be provided on a separate circuit terminated in its own electrical panel from a standby source if available. Capacity will be dependent on the installed equipment. The door shall be a minimum of 910 mm (36 ft) wide and 2000 mm (80 in) high, without doorsill, and fitted with a lock. Larger equipment may require a double door 1820 mm (72 in) wide and 2280 mm (90 in) high without doorsill and a removable center post. Portable fire extinguishers shall be provided and maintained per applicable local codes.

In addition there shall be main terminal space within the ER as shown below:

Gross Floor Space Served		Wall Length		Floor Space Dimensions	
m^2	ft^2	mm	in	mm	ft
1000	10,000	990	39	3660 x 1930	12 x 6.5
2000	20,000	1060	42	3660 x 2750	12 x 9.0
4000	40,000	1725	68	3660 x 3970	12 x 13.0
5000	50,000	2295	90	3660 x 4775	12 x 15.5
6000	60,000	2400	96	3660 x 5600	12 x 18.5
8000	80,000	3015	120	3660 x 6810	12 x 22.5
10000	100,000	3630	144	3660 x 8440	12 x 27.5

6.5.5 Entrance Facility

The entrance facility EF consists of the telecommunications service entrance to the building. All carriers and telecommunications providers involved in providing services to the building shall be contacted to establish their requirements. The actual building entry should avoid other utilities (electrical, water, gas, and sewer) if possible. Alternate redundant entrance facilities should be considered where security or continuity of service is important. The EF shall be dedicated to the telecommunications function and related support facilities and not shared other building functions nor shall water pipes, ductwork, pneumatic tubing, etc. pass through the EF. Basic methods of provisioning the service entrance pathway are underground, buried, aerial and tunnels. The choice is a compromise between cost, flexibility, expandability, and protection. In general the building will have three 103 (4) trade size conduits for large multi-pair telephone cables and three 53 (2) trade size conduits for optical fiber and/or CATV cables. These should be tilled slightly upward as they enter the building to prevent water ingress.

6.5.6 Fire stopping

Fire stopping shall be used whenever a fire-rated wall, ceiling, or floor is penetrated by communications facilities. A qualified system or design approved and tested by an independent laboratory for use in the specific penetration. The function of the fire stop is to prevent fire, smoke, or water from passing through a barrier. This applies to building construction and renovation. It should be emphasized that the installer (personnel and organization) are liable both financially and criminally for failure to follow proper fire stopping procedures. In the case of incomplete fire stopping during installation, it may be required to have a fire watch. In any case if communications cables are installed in improperly protected fire barrier penetrations, the person and firm installing the last cable is responsible for fire stopping the entire bunch of cables. Contact a qualified vendor of fire stop systems or hire a subcontractor to perform all fire stopping.

6.6 Grounding and Bonding

The grounding and bonding specification is derived from a combination of the NFPA NEC Article 250 and Chapter 8 and TIA/EIA-607. It provides a telecommunications grounding infrastructure within buildings that use telecommunications equipment and cabling. The telecommunications grounding infrastructure in conjunction with the building's electrical power grounding system and lightning protection system make up the building grounding system. The infrastructure provides a ground reference for telecommunications systems within the EF, TR, and ER. It also bonds pathways, cable shields, conductors, and hardware within those areas. The specification is primarily intended for new buildings, but will act as a guide for improvements during renovations in existing buildings.

The components that make up the grounding infrastructure include:

Grounding electrode system (ground rod)
Grounding electrode conductor
Bonding Conductor for Telecommunications
Telecommunications Bonding Backbone (TBB)
Telecommunications Main Grounding Busbar (TMGB)
Telecommunications Grounding Busbar (TGB)
TBB Interconnecting Bonding Conductor (TBBIBC)

Bonding refers to the permanent joining of metallic parts. This can be accomplished either by an exothermic weld or by irreversible two-hole compression connectors. Non-bonded grounding connections only require an irreversible one-hole compression or screw/bolt connector. The minimum gauge of wire is 6 AWG, but can get as large as 3/0 AWG. It should be noted that this is in the process of being upgraded to larger conducts dependent on distance in the near future. The grounding conductor is either green insulated or marked with green tape, but should never be a bare conductor. Licensed electricians usually install the grounding electrode system and conductor. The telecommunication installer and design are only concerned with the resistance of this system. Although the NEC requires a minimum resistance to earth of 25 ohms, telecommunications systems require a lower resistance, typically ten (10) ohms or less. Check with the major equipment suppliers such as your PBX to see what resistance the manufacturer requires. When enclosing grounding conductors in ferrous metallic conduit they shall be bonded to both ends of the conduit. The bonding conductor for telecommunications can be installed by the electrician or the telecommunication installers, but must be connected to the electrical service grounding system by an electrician. The bonding conductor for telecommunications terminates in the EF onto the TMGB. Typically there is only one (1) TMGB per building. The TMGB is a predrilled electro tin-plated, copper busbar with standard NEMA bolt hole sizing and spacing. Field drilled holes are not allowed. The TMGB is 6 mm (1/4 in) thick by 100 mm (4 in) wide and of variable length as needed. The TMBG shall be installed near the ceiling to prevent physical damage. The TMGB is mounted on 50 mm (2 in) insulated supports.

Each TR will have a TGB installed in the same manner as the TMGB. The TGB is exactly the same as the TMGB except that it is 50 mm (2 in) in width. The TGBs are bonded to the TMGB using TBBs using the shortest possible straight-line path. TMGB and TGB should be bonded to building structural steel where possible. Where multiple TRs are needed they are bonded together on every 3rd floor with the TBBIBC. This infrastructure balances the electrical potential on the grounding system.

Ancillary telecommunications components that shall be grounded include the demarcation circuit protectors (with UL497 primary protectors), all racks, cable trays, conduits and ScTP components.

6.7 Administration and Testing

6.7.1 General

Administration is the method for labeling, identification, and documentation during initial installation and as needed to implement moves, additions, and changes of the telecommunication infrastructure.

6.7.2 Component Identification and Cable Numbering

The following system of component labeling shall be used:

BBB - Building location Identifier – 3 alphabetic characters

FF - Floor # 00 to 99 – 1 or 2 numeric characters
(Note: All floors below street level 1st floor will be 00)

T – Telecommunication Room Designation – 1 alphabetic character (A to Z)

R – Rack or Terminal Block Section - 1 numeric character (1 to 9)
(Note: Data centers will use a grid system to denote location)

P – Patch Panel or Terminal Block – 1 or 2 alphabetic characters (A to ZZ)

XX – Cable Number – 2 numeric characters (01 to 99)

When cables terminate in a multi-slot equipment chassis, the cable number will be expanded to denote slot and port in the format SS.XX.

SS - Slot Number – 1 or 2 numeric characters

All TRs will be labeled with the FFT designation to indicate floor number and TR number. Racks or wall-mounted terminal block sections or shelves will be identified with the FFTR designation. Patch panels and/or terminal blocks will be identified with the FFTRP designation from top to bottom. Cables will be identified with the entire seven (7) character designation FFTRPXX. Examples follow:

HOB-15B – 2nd communications room on 15th floor at Howard Office Bldg

HOB-15B9 – 9th rack in 2nd TR on 15th floor at Howard Office Building

15B9G – patch panel in 7th position of 9th rack in 2nd TR on 15th fl

15B9G67 – 67th cable, patch panel 7th position of 9th rack in 2nd TR on 15th fl

Note: Building designation is implied information, and therefore optional, on panel and cable designations.

Panel designations will be 1.75 inches (1U) in height. The panel in the highest position will be designated “A”, with subsequently lower panels designated “B”, “C”, “D”, “Z”, then “AA”, “AB”, “AC”, etc. in 1.75” increments. Upon installation in a rack, the position of the top edge will determine its designation letter. Panel positions must be clearly labeled on both the right and left side (front only) upon rack installation.

All designations and labels will be computer generated (no hand written labels). Cables will be labeled in at least three (3) places: on the cable behind the faceplate, on the faceplate outlet front, and on the cable entering the patch panel jack or terminal block. Termination field shall be color-code for easy identification as follows:

Color	Field Type
Orange	Demarcation Points (LEC and other providers)
Green	Network Connections (Network equipment)
Purple	Common Equipment (PBX, LAN, multiplexer, switches)
White	1st Level Backbone (MC to IC or TR)
Gray	2nd Level Backbone (IC to TR)
Blue	Work Area Cable (Horizontal)
Brown	Inter-building Backbone (Campus cabling)
Yellow	Miscellaneous (Auxiliary, alarms, security)
Red	Key Telephone Systems

Designations and labels must be made of polyester (mylar) material and be capable of maintaining adhesion at a temperature equal to 200 degrees Fahrenheit. Cable labels must be self-laminating. Label content must meet the following specifications:

Rack labels must have a 3/8 inch minimum character height. Label must be affixed to the front of the rack at the highest possible location.

Panel labels must have a ¼ inch minimum character height and be affixed to the front of the panel in a location that is not obstructed by cables or wire management devices.

Wall plate labels must have a ¼" minimum character height and be affixed to the most suitable location on the face of wall plate. As indicated previously, a self-laminating label containing the same information as the face of the wall plate will be affixed to the cable jacket within four inches of termination point.

Patch Cord labels must be self-laminating, have a ¼" minimum character height, and be affixed to the most suitable location within 4" of each connector. Patch cords must be labeled at both ends with the 7 digit identifier of each endpoint using the following format: FFTRPXX | FFTRPXX (identifiers may appear on separate lines). Patch cords for which both ends terminate in the same TR, the identifier can be abbreviated to RPXX | RPXX

Based on examples within TIA/EIA-606 a complete set of records documenting initial installation and changes to it. The records should include the test results, what is installed, where it is installed (description and floor plan location), and a basic block diagram. These records should include the personnel, dates, building name and/or street address, and ambient conditions. A copy of all test data, change control forms, Wiring Standards (this document), and blank labels of various sizes, must remain in the TR.

6.7.3 Field Testing

Transmission performance depends on cable characteristics, connecting hardware, patch cords and cross-connect wiring, the total number of connections, and observing installation practices. Field testing gives a pass/fail indication of the installed system. All category 5e systems shall be tested and the results submitted for system acceptance for each 4-pair UTP/ScTP link. Test results shall also include the site information, cable number under test, and environmental conditions. Only permanent link testing will be required. It should be noted that permanent link testing is different than basic link testing in that it excludes test cables through software in the test instrument. Test instruments shall be field calibrated before testing begins and whenever a break from testing of over an hour occurs. The test instrument must be adjusted to the NVP of the particular manufacturer's installed cable type. Factory calibration and certification is required at least once every year. Acceptance testing will not be approved using test instruments with expired calibration certifications. Even though the complete channel testing, which includes the permanent link portion as well as work area and equipment cords, effects system performance, it is understood that the work area and equipment cords will not be installed at time of system acceptance and may not be supplied by the installer. Additional channel testing may be required when work area and equipment cords are installed. All system testing is performed without signals on the cabling plant. Testing shall be performed by a BICSI certified Technician Level installer. An acceptable test instrument would be a Level IIe certification tester than can print a hardcopy or send the test results to a computer/disc. All tests except wire map, length, and propagation delay will be sweep tested from 1 MHz to 100 MHz. Only the 100 MHz expected results are shown below.

The following test parameters (at ambient temperature of 20 degrees Celsius) are required of each category 5e link:

Test Parameter	Results
Wire map	All 8 conductors terminated on the proper T568B2 pins
Length	Max of 90 m (295 ft) – NVP adjusted for cable type
Insertion loss	Maximum of 21.0 dB at 100 MHz
NEXT loss	Maximum of 32.3 dB at 100 MHz (worst case)
PSNEXT loss	Maximum of 29.3 dB at 100 MHz
ELFEXT	Maximum of 18.6 dB at 100 MHz (worst case)
PSELFEXT	Maximum of 15.6 dB at 100 MHz
Return loss	Maximum of 12.0 dB at 100 MHz
Propagation delay	Maximum of 498 ns at 10 MHz
Delay skew	Maximum of 44 ns (worst case, pair-to-pair)

The only field test for optical fiber is link attenuation. Horizontal and centralized optical fiber cabling links need only be tested at one wavelength 850 or 1300 nm for multimode fiber in one direction for acceptance testing, however if lack-of-performance indicates, testing in both directions and both wavelengths may be necessary. Horizontal testing will be in accordance with ANSI/TIA/EIA-526-14-A, Method B, One Reference Jumper.

Type of Installation	Results
Horizontal	Less than 2.0 dB - 90 m (295 ft)
Open office w/CP	Less than 2.75 dB - 90 m (295 ft)
Open office w/MUTOA	Less than 2.0 dB - 90 m (295 ft)
Centralized	Less than 3.3 dB - 300 m (984 ft)
Centralized w/CP	Less than 4.1 dB - 300 m (984 ft)

Backbone single-mode optical fiber testing shall be performed at both 1310 and 1550 nm in one direction in accordance with ANSI/TIA/EIA-526-7, Method A.1, One Reference Jumper. Backbone multimode optical fiber testing shall be performed at both 850 and 1300 nm in accordance with ANSI/TIA/EIA-526-14A, Method B, One Reference Jumper. Due to the backbone length and number of splices use the following equation to calculate the expected link attenuation:

Link attenuation = Cable attenuation + connector insertion loss + splice insertion loss

Where: Cable attenuation (dB) = Attenuation coefficient (dB/km) x Length (km)

Attenuation coefficients are: 3.5 dB/km @ 850 nm for multimode
1.5 dB/km @ 1300 nm for multimode
1.0 dB/km @ 1310/1550 nm for single-mode

Connector insertion loss (dB) = 0.75 dB per connector pair

Splice insertion loss (dB) = 0.3 dB per splice

6.8 General Guidelines

6.8.1 Placement of Cables

Cables and components shall be visually inspected for proper installation. Cable stress such as tension in suspended cables or tightly cinched bundles should be minimized. Cable ties used to bundle cables should be applied loosely (hand tight) to allow the cable tie to slide around the cable bundle. Cable sheath shall not be deformed either by ties or placement. Velcro hook and loop cable ties or ISO 9000 complaint lightweight twine may be used. **Nylon cable ties are not permitted**.

6.8.2 UTP/ScTP Cables

The minimum bend radius, under no-load conditions, for 4-pair UTP cable shall be four (4) times the cable diameter, eight (8) times for 4-pair ScTP cable, and ten (10) times for multi-pair cable. Maximum pulling tension for 4-pair UTP cable is 110 N (25 lbf), use manufacturer's guidelines for other cable types.

Cables shall be terminated with category 5e (or higher) connecting hardware. This includes: impact terminal blocks, patch panels and cords, and cross-connect jumpers.

To maintain cable geometry, remove only as much cable sheath as necessary to terminate the cable pairs as per manufacturer instructions. Category 5e cable pair twists shall be maintained to within 13 mm (0.5 in) from the point of termination (category 3 twists shall be within 75 mm (3 in).

Patch cords shall follow the specifications under Section 4.4. Unjacketed jumpers shall not be made in the field by removing the sheath of jacketed cable. Cross-connector jumper wires shall be category 5e cross-connect wire of 1- to 4-pair manufacture.

Whenever service loops for extra cable slack is desired, UTP/ScTP cable shall be loosely coiled into figure eight's to prevent degradation of return loss and NEXT performance.

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

6.8.3 Optical Fiber Cabling

Fiber optic cables terminated in any location other than a work area (TO) must use LC type connectors.

The bend radius for intra-building 2- and 4-fiber horizontal optical fiber cable shall not be less than 25 mm (1 in) under no-load conditions. When under a maximum tensile load of 222 N (50 lbf), the bend radius shall not be less than 50 mm (2 in). The bend radius for intra-building optical fiber backbone cable shall not be less than that recommended by the manufacturer. If not known, then the bend radius shall not be less than ten (10) times the cables outside diameter under no load and not less than 15 times under tensile load.

Each cabling segment shall be installed such that odd numbered fibers are Position A at one end and Position B at the other end, while even numbered fibers are Position B at one end and Position A at the other end. This will maintain which fiber is transmit and receive in duplex applications.

Optical fiber patch cords shall consist of 2-fiber cables of the same type as in the optical fiber channel with factory-installed connectors on each end.

6.8.4 Connecting Hardware

Horizontal and backbone cabling will be terminated on connecting hardware that meets ANSI/TIA/EIA-568-B.2 and -B.3. These terminations shall not be relocated to implement cabling system moves, adds, or changes. All connections between horizontal and backbone cables shall be cross-connects consisting of cross-connector jumpers and terminal blocks or patch cords and patch panels.

Situations in which telephone/voice terminations are terminated on category 5e 110-style terminal blocks, a service loop (described in section 8.2) long enough to reach a logical rack placement in the TR is required. Data/LAN terminations shall be on category 5e patch panels. Other category 5e solutions may be approved by Metro for special or non-standard applications including equipment manufacturer requirements including 66-style, Krone, and/or BIX termination blocks. Whether installed on walls or in racks, connection hardware must be organized with sufficient space for orderly cable management.

6.9 Glossary of Terms, Acronyms, and Abbreviations

A	Ampere
AC	Alternating Current
ANSI	American National Standards Institute
AP	Access Provider
Attenuation	The decrease in magnitude of transmission strength between points, expressed in dB as the ratio of output to input signal level

AWG	American Wire Gauge
Backbone	Riser or Feeder Cables (between TR, EF, ER or floor distribution terminals)
BICSI	Building Industry Consulting Service International
Bonding	Permanent joining of metallic parts to form an electrically conductive path
Coax	Coaxial cable used mainly for video and RF (and older data systems)
CP	Consolidation Point (location for interconnection between horizontal cables into furniture pathways)
dB	Decibel(s)
Delay skew	Difference in propagation delay between any two pairs within the same cable
Demarc	Demarcation point, where operational control or ownership changes
EF	Entrance Facility
EIA	Electronic Industries Alliance
ELFEXT	Equal Level Far-End Crosstalk
EMI	Electromagnetic Interference
ER	Equipment Room
FEXT	Far-End Crosstalk
ft	Feet
GHz	Gigahertz
Ground	Conducting connection between an electrical circuit or equipment and earth
HC	Horizontal Cross-Connect (being revised to international standard of floor cross-connect)
Horizontal	Connection between the TO and HC
HVAC	Heating, Ventilation, and Air Conditioning
Hybrid Cable	assembly of 2 or more cable types of categories within 1 overall sheath (i.e. coper and optical fiber, or UTP and Coax)
IC	Intermediate Cross-Connect (being revised to international standard of building cross-connect)
IEEE	Institute of Electrical and Electronics Engineers
in	Inch
kg	Kilogram
kPa	Kilopascals
kVA	kilovolt-amperes
lb	Pound
lbf	Pound force
LC	A miniaturized version of the fiber-optic SC connector. It looks just like the SC, but is half the size with a 1.25 mm ferrule instead of 2.5 mm.
lx	Lux
m	Meter(s)
Mbps	Megabits per second
MC	Main Cross-connect (being revised to international standard of campus cross-connect)
Media	Wire, cable, or conductors (could be copper, glass, or in the case of wireless air)
MHz	Megahertz
mm	Millimeter

MMF	Multi-Mode optical fiber (usually with 50 or 62.5 um core) that carries many paths of light
MT-RJ	Duplex small form factor connector for optical fiber
Multipair	Cables with more than four pairs
MUTOA	Multi-user telecommunications outlet assembly
N	Newton
NEC	National Electric Code
NEMA	National Electrical Manufacturers Association
NEXT	Near-End Crosstalk
NFPA	National Fire Protection Association
nm	Nanometer
ns	Nanosecond(s)
NVP	Nominal Velocity of Propagation
Open office	Floor space division provided by furniture or moveable partitions instead of building walls
Patch cord	Flexible length of cable with a plug on one or both ends
Patch panel	A connecting hardware system that facilitates cable termination and cabling administration using patch cords
Pathway	A facility for the placement of telecommunications cable(s) PlenumA chamber by which environmental air is distributed
PSELFEXT	Power Sum Equal Level Far-End Crosstalk
PSFEXT	Power Sum Far-End Crosstalk
PSNEXT	Power Sum Near-End Crosstalk
SC	Older style simplex optical fiber connector
ScTP	Screened Twisted Pair
SMF	Single Mode optical fiber (usually with 8-9 um core) that carries only one path of light
SFF	Small Form Factor, optical fiber duplex connector approximately the same size as an 8P modular connector (RJ45)
ST	Older style simplex optical fiber connector
Star	Topology in which cables are distributed from a central point
STP	Shielded Twisted Pair
TGB	Telecommunications Grounding Busbar
TIA	Telecommunications Industry Association
TO	Telecommunications Outlet
TP	Transition Point
TR	Telecommunications Room (formerly TC or Telecommunications Closet)
UL	Underwriters Laboratories, Inc.
um	Micron or micrometer
UPS	Uninterruptible Power Supply
UTP	Unshielded Twisted Pair
VAC	Volts AC
WA	Work Area
X	Cross-connect
10GE	10 Gigabit Ethernet
568SC	Older style duplex SC connector for optical fiber terminations
6P4C	6-position 4-conductor modular connector (incorrectly a.k.a. RJ14) typically used for telephone instrument connections
8P8C	8-position 8-conductor modular connector (incorrectly a.k.a. RJ45) typically used for LAN/data connections

6.10 Reference Materials

TIA/EIA-526-7 *Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant - OFSTP-7,* August, 1998

TIA/EIA-526-14A *Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant - OFSTP-14A,* August, 1998

TIA/EIA-568-B.1 *Commercial Building Telecommunications Cabling Standard, Part 1: General Requirements,* May 2001

TIA/EIA-568-B.2 *Commercial Building Telecommunications Cabling Standard, Part 2: Balanced Twisted-Pair Cabling Components,* May 2001

TIA/EIA-568-B.3 *Optical Fiber Cabling Components Standard,* April 2000

TIA/EIA-569-A-5 *Commercial Building Standard for Telecommunications Pathways and Spaces, Addendum 5 - In Floor Systems,* June 2001

TIA/EIA-569-A-4 *Commercial Building Standard for Telecommunications Pathways and Spaces, Addendum 4 - Poke-Thru Fittings,* April 2000

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TIA/EIA-569-A-1 Commercial Building Standard for Telecommunications Pathways and Spaces, Addendum 1 - Surface Raceways, April 2000

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TIA/EIA-598-A Optical Fiber Cable Color Coding, May 1995

TIA/EIA-606 Administration Standard for the Telecommunications Infrastructure of Commercial Buildings, February, 1993

TIA/EIA-607 Commercial Building Grounding and Bonding Requirements for Telecommunications, August 1994

BICSI Telecommunications Distribution Methods Manual (TDMM), 9th Edition, 2000

NFPA 70 Code, National Electrical Code (NEC), 2002