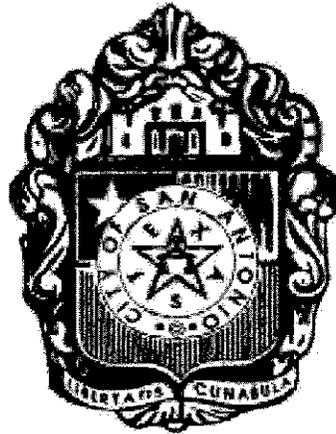


**City Of San Antonio**

**Information Technology Services  
Department**



**Cabling Standards**

Version 1.0

Bart Mulcahy  
Manager

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# **1. Scope**

## **1.1 Products and Applications Included**

A structured cabling system is a complete collective configuration of cabling and associated hardware on a premises which, when installed properly, provides a comprehensive telecommunications infrastructure. This infrastructure is intended to support a wide range of telecommunications services in a converged environment such as voice, video and data networks.

## **1.2 Responsibility**

The City of San Antonio (herein referred to as the City), Information Technology Services Department (ITSD) is responsible for the standards and management of the installation and maintenance of structured cable systems for data and voice systems, also commonly referred to as low voltage cabling.

## **1.3 Purpose**

The purpose of this document is to provide guidelines for all aspects of the installation and maintenance of these cable systems in the various facilities owned and leased by the City of San Antonio.

Adherence to the standards described in this document is vital to providing services to the various city departments and citizens serviced by City communication networks.

# 2. How to use this document

## 2.1 Qualifications, Procedures, And Products

The City Information Technology Service Department's cable standards document is divided into the following major sections with subsections providing detail.

Contractor Qualifications  
Installation Procedures  
Acceptable Products

## 2.2 Standards

Where this document conflicts with published standards, BICSI manuals, or industry best practices, this document will prevail.

Deviations from the standards described in this document must be approved by the ITSD Communications Manager or designated point of contact prior to installation.

A request for deviation must be submitted in writing and include drawings, part numbers, cut sheets, and a valid reason for deviating from the standard.

## 2.3 Changes

Recommendations or suggestions for changes are invited and must be submitted as a request for deviation.

## 2.4 Regulatory and Other Requirements

a) All information in this document is intended to conform to the National Electrical Safety Code (ANSI/IEEE C2) and National Electrical Code (ANSI/NFPA 70). Installers should always follow the NESC, NEC, applicable state and local codes, manufacturer's instructions, and contract documents when installing telecommunications cabling.

b) Only qualified persons familiar with telecommunications cabling should perform the work described in this document. It is recommended that all work be performed in accordance with NFPA 70E, *Standard for the Electrical Safety in the Workplace*.

c) General requirements for installing electrical products and systems are described in the latest version of NECA 1, *Standard Practices for Good Workmanship in Electrical Contracting* (ANSI). Other *NEIS* provide additional guidance for installing particular types of electrical products and systems. A complete list of *NEIS* is provided in Appendix D. The installation should follow the NEC, applicable state and local codes, and manufacturers' instructions for the installation of electrical and telecommunications products and systems.

d) Information within this document is intended to comply with the following standards.

- ANSI/NFPA 70-2005; *National Electrical Code*
- ANSI/TIA 455-78-B-2002; *Optical Fibres – Part 1-40: Measurement Methods and Test Procedures – Attenuation*
- ANSI/TIA 598-C-2005; *Optical Fiber Cable Color Coding*
- ANSI/TIA 526-7-1998; *Optical Power Loss Measurements Of Installed Single-mode Fiber Cable Plant*
- ANSI/TIA 526-14-A-1998; *Optical Power Loss Measurements Of Installed Multimode Fiber Cable Plant*
- ANSI/TIA 568-B Series-2001; *Commercial Building Telecommunications Cabling Standard*
- ANSI/TIA 606-A-2002; *Administration Standard for the Telecommunications Infrastructure of Commercial Buildings*
- ANSI/J-STD 607-A-2002; *Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications*
- ANSI/TIA 569-B-2004; *Commercial Building Standard for Telecommunications Pathways and Spaces*
- TIA/TSB 140-2004; *Additional Guidelines for Field-Testing Length, Loss and Polarity of Optical Fiber Cabling Systems*

# 3. Qualifications

## 3.1 Contractor

Qualified cabling contractors must be a PCI, Panduit Certified Installation company and have a BICSI Registered Communications Distribution Designer (RCDD) on staff. BICSI Certified Technicians are preferred, but not mandatory.

## 3.2 Technicians

Cable technicians must be capable of working independently and serving as a “lead tech” with the following current certifications. Refer to the list of qualifications.

Panduit Copper certification.

Panduit Fiber certification.

The duties and responsibilities of a cable technician include basic skills for the Information Transport Systems (a.k.a., telecom, voice & data, or structured cable) industry. Basic skills such as the ability to install and terminate copper and fiber optic cable; build out equipment rooms, closets and racks; setup configure and use copper and fiber optic test equipment; read and understand blue prints and related technical documentation; and perform overall installations according to industry standards, best practices, and manufacturer specifications.

The cable technician must be able to demonstrate and perform the following:

- Perform Site Surveys
  - Use Construction Plans and specifications
  - Conduct visual site survey and inspections
  - Pull horizontal cable
    - In conduit
    - In open ceiling
  - Pull optical fiber optic cable
    - In innerduct
- Build-out Equipment Rooms (Closets)
  - Determine equipment layouts
  - Mount/install backboards
  - Mount/install cross terminals
  - Mount/install racks & patch panels
  - Install optic fiber panels & hardware
- Install Grounding Infrastructure
  - Know electrical codes
  - Know *National Electric Code*®
- Termination
  - Complete IDC terminations (i.e., 66, 110)
    - Terminal blocks
    - Patch panels
    - RJ-45 connector
- Connectors
  - Assemble and install
    - modular plugs (RJ-45)
    - Coaxial connectors
    - Crimp connectors
    - Optical fiber connectors
      - ST, SC & LC
  - Demonstrate color codes (T-568A/B)
- Testing
  - Copper Category 5e/6 certification using hand held test equipment (Fluke,

- Install grounding backbones & busbars
- Installation of Work Area Outlets
  - Wall
  - Floor
  - Power pole & modular furniture
  - RJ-45 connector
  - Modular jacks
- Pulling Backbone Cable
  - Pull backbone cable
    - Bottom up or top down
    - Horizontal to floor and ceiling
- Firestopping
  - Core firewall
  - Install sleeves
  - Pull cable
  - Install intumescent materials and backing
- Pre-termination
  - Organize, form, dress cable
  - Determine length & slack required
  - Label cables
- WireScope)
  - Optical fiber; Single & Multimode using a light source and power meter
- Troubleshooting
  - Diagnose, identify, and correct
    - Copper cable problems
    - Optical fiber cable problems
- Retrofits
  - Identify active circuits
  - Implement cutover
- Administrative Tasks
  - Document test results
  - Document as-built drawings (red lines)
  - Complete daily reports
  - Order/inventory materials
- Remain current on industry best practices and manufacturer requirements
- Keep up with standards and codes

### 3.3 Test Equipment

The contractor must have cable certification test equipment capable of certifying Category 5e, Category 6, and multi mode and single mode fiber optic cable installations, such as the following. Technicians must be proficient with the test equipment being provided by the contractor.

Agilent, WireScope Pro or most current  
 Fluke, DTX-1800 or most current  
 Ideal, LanTek6 or most current

### 3.4 Tools

The contractor is responsible to insure that each technician has and maintains the tools and other equipment necessary to perform the specific tasks assigned.

Personal hand tools, refer to the attached list.  
 Ladders, refer to the attached list.  
 Cable test and certification equipment

### 3.5 Mandatory Tools for Cable Technicians

D814 Punch Tool with 66 Blade  
 D814-88 Punch Blade

4" Straight Screwdriver  
6" Straight Screwdriver  
4" Phillips Screwdriver  
6" Phillips Screwdriver  
Snips  
Side Cutter  
Wire Strippers  
Flashlight, 2-AA batteries  
Small Tool Bag or Tool Box  
Pliers  
Needle Nose Pliers  
Channel Lock Pliers  
Utility Knife  
Adjustable "Crescent" Wrench  
3/8" Drive Ratchet and Socket Set  
12" Hack Saw  
10" Sheetrock Saw  
Tape Measure  
16-oz. Hammer  
Punch or Scratch All  
Torpedo Level  
Toner and Tracer  
25-ft. Fish Tape  
Cordless Drill  
Large Tool Bag or Tool Box  
Digital Multimeter (volt-ohm meter)  
Mod Tap SLT3  
Buttset  
Soft Side Technician Bag  
RJ-Crimp Kit (RJ-45/11)  
RG58, RG59, and RG11 Crimper  
Pin Crimper  
Coax Stripper  
Soldering Iron

### **3.6 Installation Team & Special Tools (on van or truck)**

6-ft., Fiberglass, Type I, 350 Lb., Step Ladder (2)  
8-ft., Fiberglass, Type I, 350 Lb., Step Ladder (2)  
Corded Heavy-Duty Hammer Drill  
Cable Spool/Reel Jacks  
Manufacturer Specific Crimp/Termination Tools  
Cable Test/Certification Equipment  
WireScope Pro or 350; Fluke DSP-4000 or DTX; LanTek 6 or 7  
2-Wheel Hand Truck (dolly)

# **4. Acceptable Products**

## **4.1 City Inside Plant Standards**

The City has standardized on the following products for copper and optical fiber installations.

- Copper connectivity products – Panduit
- Copper cable – General or Panduit Cable Manchester
- Optical fiber connectivity – Corning or Panduit
- Optical fiber cable – Corning
- Equipment cabinets or racks – Chatsworth
- Grounding and bonding – Chatsworth or Panduit
- Cable support – Erico/Caddy or Panduit

The City may substitute other manufacturers as needs arise.

Deviations must be requested as described in the How to Use This Document section.

# 5. Network Installation Summary

The following section is a summary of installation requirements. These items are discussed in more detail throughout this document.

## 5.1 Building Connectivity

The City employs various communication services for building connectivity. The following communications services are commonly used:

- Carrier-based (Telco) Point to Point T-1
- Carrier-based cable modem service
- Carrier-based Ethernet with a copper 8PC handoff
- Carrier-based Ethernet with a multi-mode (LC) handoff
- Private Ethernet with a copper 8PC handoff
- Private Ethernet with a multi-mode fiber (LC, SC, and ST) handoff
- Private Ethernet with a single-mode fiber (LC, SC, and ST) handoff
- Private Optical (OC-48, OC-192) fiber with single mode fiber (LC, SC) handoff

## 5.2 MDF/IDF Room Architecture

A MDF/IDF Room provides a controlled environment to house telecommunications equipment and connecting hardware. It is also the demarcation point for all Facility, Backbone, Riser and horizontal cabling. This room is not to be shared with Electrical service, Security, Paging, Video Surveillance or alarm systems. This room should be located as close to the center of the building as possible.

The minimum dimensions for the MDF/IDF is 6' x 8' with a 9' ceiling and a 36" door opening outward. This room will support up to 80 City Personnel.

For buildings that house more than 80 people the minimum MDF/IDF size shall increase to 10' x 10' with a 9' ceiling and an outward swing 36" door. ITSD should be contacted during the design phase to determine final room layout.

On buildings requiring a MDF and one or more IDF'S the distance between rooms should be limited to 180 meters.

Within this document there are "rules" and "guidelines". The rules shall be followed precisely, while the guidelines should be applied using common sense and improvising where necessary.

### 5.2.1 Plywood Backboard

One wall in any MDF/IDF will be completely covered with 3/4" fire rated plywood with stamps visible for inspection and if possible placed on a permanent wall and no more than 12" above

finished floor level. Fire rated Plywood backboard should never be painted and the fire rated stamps shall be visible after installation. In the event that non fire-rated backboard is used, two coats of flame-retardant paint shall be used to paint the plywood.

Plywood backboards shall be used for installing AT&T, Time Warner, Grande and other service providers and other equipment requiring wall mounting. Any riser/backbone cable that may require lightning protection/bonding and should also be mounted on the wall

### **5.2.2 Cable Entry**

Backbone and Riser Cable entry – floor/ceiling – should be located on the plywood covered wall starting on the left side of the wall. Protectors shall be terminated on this wall converting from underground cable to inside cable and extended into the data cabinet. This installation is pre-engineered and the work done by contractors.

Conduit or sleeve should penetrate the walls 6”, with ends protected by plastic, or other appropriate bushings, to prevent cable abrasion during installation.

### **5.2.3 Fire Stopping**

Fire stopping material shall be in place after all cable and wire construction involving penetration through fire barriers.

### **5.2.4 Grounding**

Grounding is the electrical connection to earth, normally through the earth electrode system and must comply with local fire code.

Aluminum cable sheath as well as protectors shall be grounded using #6 copper running to the building ground (Electrical ground, or a ground rod, specified on the original engineering drawings).

Additionally, all racks, cable trays, and shelving shall be grounded using #6 copper running to building ground when compatible with required electrical codes, the grounding instructions and requirements of the equipment manufacturer should also be followed. Cable tray that is bolted together (metal-to-metal connection) needs to be grounded with grounds straps after bonding has occurred.

### **5.2.5 Bonding**

Bonding is the electrical connection between two metallic surfaces to provide a low resistance path between them.

Bonding shall be by #6 copper, cabinet to cabinet or cable tray to cable tray. Paint will have to be removed on painted surfaces to ensure a good connection.

### **5.2.6 Arranging Equipment Cabinets within the MDF/IDF Room for 80+ Personnel**

The following guidelines shall be observed concerning the arrangement of equipment cabinets within the MDF/IDF rooms: See Figures 1-1, 1-2, and 1-3.

**Note:** Paragraphs A and B refer to the distance between the equipment cabinets and the reference wall. Designers should take into consideration the equipment to be placed in a rack when laying out rack placement within a room.

A. There shall be no less than 48” clearance between the front, rear, or side of an equipped rack and a wall with a communications components on it.

B. There shall be no less than 36” clearance between the front, rear, or side of an equipped rack and a blank wall (communications facilities).

**Exception:** The side of a cabinet, or row of cabinets, may be placed closer than 36” to the wall provided that easy access to both the front and rear of the rack is not compromised.

### **5.2.7 Equipment Cabinets**

Equipment cabinets shall be used in all MDF/IDFs. Chatsworth 42U TerraFrame cabinets should be used for all new installations or in existing installations where there is adequate room. The top of all wall mounted cabinets are to be 72” above the floor. These cabinets shall be lined on both sides of the mounting rails with Panduit wire managers with fingers of 3.3”. In the event that a Terraframe cabinet will not fit, a Chatsworth CUBE-IT, or equivalent may be used, and shall be 24”, 36” and 48” wall mounted or 60”/72” wall mounted floor supported depending building requirements. All cabinets are 30” deep and for installations of 80 personnel or less. In the event that a Chatsworth CUBE-IT will not fit and the communications facilities are in an enclosed room, a Chatsworth floor mounted two-post cabinet will be used. In the event that a Chatsworth floor-mounted cabinet will not fit or the communications facilities are not in an enclosed room, a Chatsworth wall-mounted cabinet will be used.

### **5.2.8 Cabinet Labeling**

Each rack shall be labeled on the front center at the top and bottom of the rack with one-inch high numerals. Use a self adhesive type label maker. The first rack in a row or lineup served by a cable tray shall be labeled rack #101. The second rack in that lineup shall be labeled #102, etc.

### **5.2.9 Arranging Equipment Within the Data Cabinet**

Placement of equipment in each rack shall be specified by EIA mounting space position. One EIA mounting space equals 1.75 inches. Mounting spaces count from bottom of the rack.

Rack load shall not exceed manufacturers recommended limit.

A minimum of four mounting spaces should be left at the top of the cabinet for a fiber LIU. This should be followed by a one U wire manager and then the required number of 48 port

patch panel for Cat 5e/6 cables with a one U wire manager between each. There should be space left on the patch panel allowing for a 20% growth.

If a Riser/Tie cable is required it shall follow the Cat 5e/6 wire following the same sequence of patch panel and wire manager.

The Data equipment can now follow with wire manager above and below each piece of equipment.

A rack mounted UPS shall be installed in the bottom of the data cabinet.

Small standalone devices are not to be placed on the floor, or stacked on top of each other within an equipment rack. A separate wall mounted/rack mounted shelf shall be furnished for this equipment.

## **5.3 MDF/IDF Room Cable Tray Systems**

As required by Terra frame installations.

## **5.4 Cable Management**

This section outlines the rules for routing all cable and wire within all MDF/IDF rooms.

A. All cables originating on the front of a patch panel or device, or connecting within a rack or between racks shall be routed through whatever rings, brackets, or Velcro straps are provided on either side of the rack. If no such rings or brackets are present, they shall be added.

B. The cables shall be routed symmetrically. That is, cables originating on the right half of the cabinet shall be routed through the rings or brackets on the right side of the cabinet, those originating on the left half shall be routed on the left side of the rack.

C. Upon completing a circuit disconnect, the jumper/patch cord shall be removed to eliminate the possibility of snagging and as a positive indication the port is unused. This does not apply at locations with dedicated port assignments.

## **5.5 MDF/IDF Room Environment**

MDF/IDF room environmental requirements are important factors contributing to equipment performance, reliability and employee effectiveness.

### **5.5.1 Temperature and Humidity Standards**

The following Heating, Ventilating and Air Conditioning (HVAC) standards shall be observed in all MDF/IDF rooms:

The temperature of any MDF/IDF room should be maintained between 55° F and 78° F.

The relative humidity of any MDF/IDF room should be maintained between 14% and 45%.

### **5.5.2 Lighting Standards**

MDF/IDF rooms shall have sufficient lighting so that Maintenance and other personnel can easily see labels, equipment ports, and any other item of interest in the room including communications facilities. Lighting shall not be placed directly over cable trays.

### **5.5.3 Interior Finishes**

Floors, walls, and ceilings shall be treated to eliminate dust. Finishes shall be light in color to enhance room lighting. Flooring materials having antistatic properties shall be selected. Sealed concrete or tiled floors are recommended. Carpet or rugs are not permitted in MDF/IDF rooms. Existing MDF/IDF rooms not in compliance with this requirement that contain electronics are to be reconditioned as soon as conditions allow.

### **5.5.4 Electrical Power Standards**

The following electrical power standards should be observed in all communications rooms:

The standard service is two dedicated 120 VAC, 60 Hz outlets protected by a 20A circuit breaker and should be located on the cable tray directly above the cabinet. In the event that the outlets cannot be mounted above the cabinet, the outlets should be mounted either directly behind a floor-mounted cabinet or directly below a wall-mounted cabinet approximately 18” from the floor. In addition, a dedicated 120 VAC, 60 Hz outlet protected by a 20A circuit breaker should be installed on the wall that is covered with plywood for service providers approximately 18” from the floor.

Non-standard service is provided on a case-by-case basis to equipment requiring different service and require approval from the ITSD Communications Manager or his designated point of contact.

At locations where a Terra Frame is installed at least one 208v 30 amp and one 208v 20 Amp outlet should be located on the cable tray directly above the cabinet. In the event that the outlets cannot be installed above the cabinet, the outlets should be mounted on the wall directly behind the cabinet approximately 18” from the floor.

**Note:** When the equipment in a particular rack exceeds the capacity of the existing service outlets or associated 20A circuit breaker, installing additional service outlets dedicated to a second 20A circuit breaker is permissible.

Each MDF/IDF shall have a dedicated sub-power panel if requirements are sufficient enough to justify the cost. Each outlet in the room shall be clearly marked with panel and circuit designations. An isolation transformer may be included in the room design where known contaminated power exists.

An Equipotential Ground shall be maintained throughout each MDF/IDF Room. This is accomplished by designing so that no daisy-chained ground shall be extended farther than 20 feet from the first rack connected to a common ground. This means that when a point is reached that is 20 feet from the initial relay rack another run shall be made back to the common ground.

A design goal of 10 ohms resistance to earth ground will be used for all MDF/IDF Rooms. (MIL-STD-188-124A, Earth Electrode System for Communications Electronics).

All cabinets, cable trays, and shelving shall be connected to building ground as required by NEC article 250.

Care should be taken not to load a 20A circuit more than 16A normal operating current (by code).

Orange outlets indicate isolated ground and/or shielded power. These outlets are only to be used for Telecommunications and Test Equipment. Use of these dedicated outlets for other devices (i.e., vacuums, drills, etc.) can lead to disruption of telecommunications services. Isolated ground circuits differ from standard circuits in that they guarantee a hard wired ground (3 wire circuit) back to the electrical panel. Standard circuits are two wires back to the panel, with the ground provided by the conduit.

A minimum clearance of 36" shall be maintained in front of electrical panels per National Electrical Code 110.16. When considering clearance please take into account the depth of the electronic chassis to be installed in the rack.

### **5.5.5 Housekeeping**

The following housekeeping guidelines shall be observed in all MDF/IDF rooms:

There should be no storage of items in the communications rooms.

Electronic equipment should not be stored as a spare in any MDF/IDF room.

No food or drink is allowed in any MDF/IDF.

A garbage receptacle, broom, and dustpan should be located within the MDF/IDF room, and each individual is responsible for clean up. The garbage receptacle and all contents should be removed from the room and stored properly after the job is completed or at the end of the day.

### **5.5.6 Security**

MDF/IDF rooms contain critical equipment.

Doors should not be propped open, and positive door closures should be observed. Doors should be locked when the room is unattended. The data cabinet doors shall be locked upon completion of work performed in the cabinet.

## 5.6 Quality Assurance

This section describes the quality assurance procedure for MDF/IDF rooms.

### 5.6.1 Acceptance Procedure

An ITSD Cabling Plant Project Manager or designated representative shall inspect MDF/IDF rooms during new building construction or when cable and equipment work is done. Prior to any MDF/IDF room being accepted, all work shall meet engineering specifications, or appropriate standards stated within this document, or the current issue of Copper Wire and Cable Engineering Standards Procedure 201.16. For cable work, all installed pairs shall be tested using appropriate test equipment and the reading will be retained as a benchmark. For cable pair acceptance, all installed pairs shall be tested according to Engineering guidelines. All pairs shall be good and usable, with no defects.

## 5.7 Wiring Specifications

All wiring is to be installed according to the EIA/TIA wiring codes and shall adhere to all local wiring codes. All wire shall be terminated using the T568B wiring practices. All cable shall be Plenum rated.

Cat 5e cable used for Voice/Data applications shall have a Blue jacket terminated on Black jacks in the MDF/IDF and Electrical Ivory at the desktop.

Cat 5e cables used for wireless applications shall have a White jacket terminated White jacks in the MDF/IDF and RJ45 plugs at the field end.

Cat 5e cables used for A/V applications shall have a Violet jacket and shall be terminated on Violet jacks in the MDF/IDF and Violet jacks at the field end.

Cat 5e cables used for security applications shall have a Red jacket and terminated on Red jacket in the MDF/IDF and Red jacks at the field end.

Cat 6 cables used for Voice/Data applications shall have a Yellow jacket and terminated on Yellow jacks in the MDF/IDF and Electrical Ivory at the desktop.

Special colored or special use jacks at the customers request may be substituted at the field end with permission from the ITSD department.

Walls are to be dropped and wires concealed where possible with jacks located at a standard 18" height.

All cables shall be labeled on both ends and tested using a CAT 5e/6 certified test unit and results presented electronically to the ITSD department.

All cable pulled through a conduit in a floor or underground application shall be Underground Rated.

## **5.8 Floor Outlets**

Floor boxes installed during the concrete pour or added to a building at a later time shall support Hubbell SystemOne 4x4 applications. Raised floor application shall support Hubbell Recessed Application

## **5.9 Underground Conduit**

Conduit runs tying buildings together shall be buried at a depth of 36" and minimum of one 4" conduit placed in trench (actual conduit count will be determined by ITSD). This conduit shall be packed with four 1" inner duct each having a different color. There shall be 4" of flowable fill on top of the conduit and a caution marker tape placed in the trench 10" below the finished grade. A metallic wire shall be placed in the 4" conduit to provide a means of locating the pathway at a later date.

## **5.10 Aerial Cable**

All aerial cables shall have a clearance of 18' and shall have a ¼" messenger attached to the cable for support. All dead end or corner poles shall have down wire guides to relieve pole tension. Proper weather head and attachment points shall be required when cable enters a building. All building penetrations shall be sealed to prevent water and insect access.

# 6. Horizontal Cabling Standard

## 6.1 General

This section includes the Horizontal Cabling component of the Premise Distribution System. Section Includes but is not limited to:

- 100 Ohm Unshielded Twisted Pair Cable (UTP)
- Category 5E Eight –Position Modular Jacks
- Category 5E Modular Patch Panels
- Modular Faceplates
- Surface Mount Boxes
- Multi-User Telecommunications Outlet Assembly (MuTOA)

## 6.2 Products

### 6.2.1 100 Ohm Unshielded Twisted Pair Cable (UTP)

Provide 100 Ohm unshielded twisted pair cable that meets or exceeds the specifications for Category 5e UTP as defined in ANSI/EIA/TIA 568-B2-1.

Category 5e UTP cable shall be plenum rated.

#### 6.2.1.1 Mechanical Characteristics

##### 1. Pair Color Codes

- (a) Pair 1: Blue-White/with extruded Blue stripe on White single
- (b) Pair 2: Orange-White/with extruded Orange stripe on White single
- (c) Pair 3: Green-White/with extruded Green stripe on White single
- (d) Pair 4: Brown-White/with extruded Brown stripe on White single

2. The cable shall be round and manufactured such that the orientation of each pair, with respect to every other pair in the cable, is positively maintained. Each pair shall be separated from every other pair in the cable, by a physical barrier.

3. The diameter of the insulated conductor shall be 0.044 inch maximum. The insulated conductor used as the white single shall have a co-extruded colored stripe as defined in “Color Codes”. The stripe shall be of the same material as the insulation.

4. The cable shall be restricted to four-pair size to support a broad range of applications. The pair twist lengths shall be selected to ensure compliance with all requirements listed in the Transmission section.

5. The cable shall incorporate a ripcord under the jacket to facilitate jacket removal and allow easy access to the pairs.

6. The jacket shall be continuous, free from pinholes, splits, blisters or other imperfections. The nominal outside diameter of cables listed to CMP shall not exceed 0.250 inch. The nominal outside diameter of a cable listed to CMR shall not exceed 0.240 inch.

7. The cable jacket shall be printed with a minimum of the following information: Manufacturer, Manufacturer's part number, cable type, listing file number, number of pairs, listing type (i.e. CMP), and sequential footage markings. The print sequence shall be repeated every 2 feet.

8. The ultimate breaking strength of the completed cable shall be 400 N (90-lbf) minimum.

#### **6.2.1.2 Transmission Specifications**

##### **1. DC Resistance**

The DC resistance of any conductor shall not exceed 6.66 ohms per 100 m (328 ft) at or corrected to a temperature of 20° C.

##### **2. DC Resistance Unbalance**

The DC resistance unbalance between the two conductors of any pair shall not exceed 2.5% when measured at or corrected to a temperature of 20° C.

##### **3. Mutual Capacitance**

The mutual capacitance of any pair at 1 kHz and measured at or corrected to a temperature of 20° C shall be 4.6 nf per 100 m (328 ft) nominal.

##### **4. Input Impedance**

The cable shall have an input impedance of  $100 \pm 15$  ohms for frequencies from 1 to 100 MHz,  $100 \pm 22$  ohms for frequencies between 100 MHz and 200 MHz, and  $100 \pm 32$  ohms for frequencies between 200 MHz and 300 MHz.

##### **5. Return Loss**

The return loss of any pair for a length of 100m (328 ft.) shall be greater than or equal to the values listed in Table 3.1.

##### **6. Insertion Loss**

The insertion loss is derived from swept frequency signal level measurements at the output of cable lengths greater than or equal to 100 m (328 ft). The maximum attenuation of any pair, in dB per 100m, measured at or corrected to a temperature of 20° C shall be less than or equal to the values listed below:

##### **7. Near End Crosstalk (NEXT) Pair-to-Pair**

NEXT loss is derived from swept frequency measurements using a network analyzer and s-parameter test set. The minimum pair-to-pair NEXT loss for any pair combination at room temperature shall be greater than or equal to the value listed in Table 3.1.

##### **8. Equal Level Far End Crosstalk (ELFEXT) Pair-to-Pair**

ELFEXT is derived from swept frequency measurements using a network analyzer and s-parameter test set. The minimum pair-to-pair ELFEXT loss for any pair combination at room temperature shall be greater than or equal to the value listed in Table 3.1.

9. Power Sum NEXT

Power Sum NEXT is derived from swept frequency measurements using a network analyzer and s-parameter test set. The minimum Power Sum NEXT for any pair combination at room temperature shall be greater than or equal to the value listed in Table 3.1.

10. Power Sum ELFEXT

Power Sum ELFEXT is derived from swept frequency measurements using a network analyzer and s-parameter test set. The minimum Power Sum ELFEXT for any pair combination at room temperature shall be greater than or equal to the value listed in Table 3.1.

11. Table 3.1 – Category 5e Permanent Link Limits in dB per ANSI/TIA/EIA-568B.2-1

Frequency MHz	Insertion Loss	NEXT pair-to-pair	NEXT power sum	ELFEXT pair-to-pair	ELFEXT power sum	Return Loss
1.0	2.1	>60	>57	58.6	55.6	19.0
4.0	3.9	54.8	51.8	46.6	43.6	19.0
8.0	5.5	50.0	47.0	40.6	37.5	19.0
10.0	6.2	48.5	45.5	38.6	35.6	19.0
16.0	7.9	45.2	42.2	34.5	31.5	19.0
20.0	8.9	43.7	40.7	32.6	29.6	19.0
25.0	10.0	42.1	39.1	30.7	27.7	18.0
31.25	11.2	40.5	37.5	28.7	25.7	17.1
62.5	16.2	35.7	32.7	22.7	19.7	14.1
100.0	21.0	32.3	29.3	18.6	15.6	12.0

12. Propagation Delay

The propagation delay of any pair at 10 MHz shall not exceed 545ns/100m.

13. Propagation Delay Skew

The propagation delay skew between any two pairs shall not exceed 25 ns/100m at 10 MHz.

14. Dielectric Breakdown

The dielectric breakdown of the cable shall be at least 2500 volts DC conductor to conductor.

**6.2.1.3 Acceptable Manufacturer's and Cable Type**

1. Panduit
2. General

### **6.2.2 Category 5e, Eight-Position Modular Jacks (RJ-45)**

- A. Shall meet or exceed Category 5e connecting hardware specifications for all pair combinations up to 250 MHz
- B. Eight-Position with IDC termination
- C. Available in both straight and angled mounting
- D. Removable from front or rear of faceplate
- E. Compatible with both T568A and T568B wiring options
- F. Available in the following colors: Black, White, Red, Gray, Blue, Orange, Ivory, Light Ivory, Alpine White
- G. Slim design to allow jacks to be side, stacked for high density - Six outlets in single-gang
- H. Available laser-printed customized tabs
- I. Additional type modules available for fiber and coaxial F-type connectors

#### **6.2.2.1. Acceptable Manufacturer's**

- 1. Panduit

### **6.2.3 Category 5e Modular Patch Panels**

- A. 19" rack-mountable, 48-port or 24-port Category 5e patch panels shall be used for the termination of horizontal UTP cable dedicated for data applications.
- B. Shall meet or exceed Category 5e connecting hardware specifications for all pair combinations up to 250MHz
- C. Eight-Position with IDC termination
- D. Panels shall be wired for T568A configuration
- E. Panels shall occupy 1 or 2 rack units

#### **6.2.3.1 Acceptable Manufacturer's**

- 1. Panduit

### **6.2.4 Category 5e IDC Wall-Mounted Termination Blocks**

- A. Insulation Displacement Connection (IDC) type termination block shall support Category 5e applications and facilitate cross connection and interconnections using patch cords.

B. The wiring blocks shall be fire retardant, molded plastic consisting of horizontal index strips for terminating conductors. These index strips shall be marked with five colors on the high teeth, separating the tip and ring of each pair, to establish pair location. A series of fanning strips shall be located on each side of the block for dressing the cable pairs terminated on the adjacent index strips. Clear label holders with the appropriate colored inserts shall be provided with the wiring blocks. The insert labels shall contain vertical lines spaced on the basis of circuit size (3-, 4-, or 5-pair) and shall not interfere with running, tracing or removing jumper wire/patch cords.

C. The terminating block shall be able to accommodate over 500 repeated insertions without incurring permanent deformation and it shall pass the reliability test of no more than one contact failure in 10000 connections.

#### **6.2.4.1 Acceptable Manufacturer's**

1. Panduit

#### **6.2.5 Modular Face Plates**

A. Provide faceplates for telecom outlets.

1. Unless otherwise indicated, provide stainless steel faceplates with brushed finish.
2. Faceplates shall have label holders.

B. Faceplates shall accommodate the following configurations

1. Single Gang Faceplates
  - (a) One, two, three or six modules

C. May be used with flat or angled modules

D. Available in white, gray, ivory, light ivory and stainless steel.

1. Submit color for approval prior to ordering

#### **6.2.5.1 Acceptable Manufacturer's**

1. Panduit

#### **6.2.6 Surface Mount Boxes**

A. Surface mount boxes shall be available in one, two, four and six port configurations, with modules to support UTP, fiber and coax.

B. Available in black, white, gray, ivory and light ivory.

#### **6.2.6.1 Acceptable Manufacturer's**

1. Panduit

### **6.2.7 Multi-User Telecommunications Outlet Assembly (MuTOA)**

- A. Constructed of durable UV resistant, high impact plastic.
- B. Compatible with single or dual gang electrical box.
- C. Accommodates any combination of up to 18 ports of mixed media or up to 36 fibers.

#### **6.2.7.1 Acceptable Manufacturer's**

- 1. Panduit

### **6.2.8 Wall-Phone Jack Assembly**

- A. Provide stainless steel duplex faceplate equipped with mounting lugs designed to mate with corresponding telephone base plate and single 630B.

#### **6.2.8.1 Acceptable Manufacturer's**

- 1. Panduit

## **6.3 Execution**

### **6.3.1 Installation**

- A. Install all equipment and components in accordance with manufacturer's written instructions with sound engineering practices as established by EIA/TIA and in compliance with NEC and recognized industry practices, to ensure that all items comply with specifications and serve intended purposes.
- B. Contractor work force, sub-contractors and material suppliers shall review and comply with all safety, security rules, codes and regulations, applicable to construction site personnel.
- C. Horizontal Cabling
  - 1. Contractor shall supply horizontal cables to connect each information outlet to the backbone subsystem.
  - 2. Each work location shall have one or more runs of Category 5e UTP cable, placed in home run fashion from the location to the nearest intermediate telecommunications closet. Splicing of station cables is not permitted. Station cable shall be Blue in color or unless otherwise identified.
    - (A) Terminate station cable (Blue) on rack mounted 24 or 48 port modular patch panels.
  - 3. A blank cover plate shall be provided on all outlet boxes where cable is not initially installed.

4. Terminate Category 5e four-pair horizontal cable in eight-pin modular jacks at the information outlet. Eight pin modular jacks shall have insulation displacement terminals and terminated to comply with the T568A wiring configuration.
5. Eight-Position Jack Pin/Pair Assignments (Designation T568A)
 

Pair One	Pins 4/5	White-Blue/Blue
Pair Two	Pins 3/6	White-Orange/Orange
Pair Three	Pins 1/2	White-Green/Green
Pair Four	Pins 7/8	White-Brown/Brown
6. For wall-mounted telephones, terminate cable in modular jack with wall-plate for mounting telephone instrument.
7. Contractor shall observe the bending radius and pulling strength requirements of the 4-pair UTP cable during handling and installation.
8. All horizontal cabling shall be installed in conduit and/or cable tray. Cable from the tray to the wall outlet shall be routed in conduit.
9. Contractor shall install sufficient slack in cable to prevent cable service wear and to allow for access and service of the cabling system. Provide a minimum 12 inches of slack at the information outlet and 1 meter of slack at the patch panel or termination block.
10. Slack behind faceplate shall be pulled back into raceway to prevent damage to connectors.
11. Every effort will be made to schedule the requirements under this Contract in such a manner so as to complete all above ceiling work prior to ceiling tile installation. In the event the Contractor is required to remove ceiling tiles, such work shall not break or disturb grid and must be coordinated with the General Contractor.
12. Velcro cable ties shall be used on Cat 5E and Cat 6 UTP cables.

#### D. Pull Strings

1. Initial pull strings in riser conduits shall be provided by the Division 16 electrical contractor.
2. Contractor shall re-install pull strings in all riser conduits that have capacity for additional cables.
3. Contractor shall install pull strings in all inner duct.

#### E. Cable Labeling

1. Install cable labels on both ends of horizontal cable. Labels shall remain intact after termination.

#### F. Miscellaneous Equipment

1. Contractor must provide any necessary screws, anchors, clamps, tie wraps, distribution rings, wire molding, miscellaneous grounding and support hardware, necessary to provide a professional and complete installation of the System.

#### G. Special Equipment and Tools

1. It shall be the responsibility of the Contractor to furnish any special installation equipment or tools necessary to properly complete the System. This may include, but is not limited to, tools for terminating cables, testing and splicing equipment for copper/fiber cables, jack stands for cable reels, cable wenchers, personnel lifts and test equipment.

# 7. Backbone Cabling Standard

## 7.1 General

### 7.1.1 Summary

A. This section includes the Backbone Cabling standard of the Premise Distribution System for the City Of San Antonio.

B. Section Includes but is not limited to:

1. Fiber Optic Riser Cable – Single-Mode
2. Fiber Optic Riser Cable – Multimode
3. Fiber Optic Termination Hardware
4. Multi-Pair Copper Riser Cable
5. Multi-Pair Copper Riser Termination Hardware

## 7.2 Products

### 7.2.1 Fiber Optic Cable – General

A. Fiber optic cable segments shall be comprised of individual multimode and single-mode fiber optic cables. Composite cables with multimode and single-mode in a common sheath shall not be used.

B. Cables shall be UL Listed as Optical Fiber Non Conductive Riser (OFNR)

C. Cables shall be marked as required by national and local electrical codes.

D. Individual fibers shall be color coded for identification. The color-coding shall be in accordance with EIA/TIA-598 Color Coding of fiber Optic Cables.

### 7.2.2 Fiber Optic Riser Cable – Single-Mode

A. Fibers shall comply with EIA/TIA 492CAAA Standards

B. Characteristics

1. Nominal core diameter of 7um and a cladding diameter of 125um.
2. Maximum attenuation: 0.4 dB/km @ 1310 nm and 0.3 dB/km @ 1550 nm.
3. Fibers shall have D-LUX<sup>®</sup> coating or approved equivalent to ensure color retention, minimize micro-bending losses and improve handling. The coating shall be mechanically strippable.

### **7.2.2.1 Approved Manufacturer's**

1. Chromatic
2. CommScope
3. Corning
4. Systimax

### **7.2.3 Fiber Optic Cable – Multimode**

A. Compliant with EIA/TIA 492AAAC and ANSI/TIA/EIA-568-B.3.1 Standards

B. Laser-optimized 62.5um fiber

C. Characteristics

1. Dielectric, Loose Tube Construction
2. Graded index, 62.5/125 um core/cladding, dual window 850 and 1300 nanometers
3. Numerical aperture of 0.2 plus or minus 0.015.
4. Maximum attenuation: 3.0 dB/km @ 850 nm and 1.0 dB/km @ 1300 nm.
5. Minimum bandwidth: 2000 MHz/km @ 850 nm and 500 MHz @ 1300 nm.
6. Gigabit Ethernet Distances: 300m @ 850nm and 700m at 1300nm.
7. 10 Gb/s Ethernet Distances: 300m using 850nm VCSELs
8. All fibers shall be color coded to facilitate individual fiber identification. Fibers shall have D-LUX<sup>®</sup> coating or approved equivalent to ensure color retention, minimize micro-bending losses and improve handling. The coating shall be mechanically strippable.

### **7.2.3.1 Approved Manufacturer's**

1. Chromatic
2. CommScope
3. Corning
4. Systimax

### **7.2.4 Fiber Optic Connectors – Single-Mode**

A. Provide LC type fiber optic connectors on single-mode fiber optic cable with the following minimum specifications:

1. Insertion Loss of 0.2dB typical
2. Reflection of 0.2dB typical
3. Durability for 1000 rematings with less than 0.2db change
4. Provide blue boot on single-mode connectors

### **7.2.4.1 Approved Manufacturer's**

1. Corning
2. Ortronics
3. Siemon
4. Systimax

## **7.2.5 Fiber Optic Connectors – Multimode**

A. Provide LC type fiber optic connectors on multimode fiber optic cable with the following minimum specifications:

1. Insertion Loss of 0.2dB typical
2. Reflection of 0.2dB typical
3. Durability for 1000 rematings with less than 0.2db change
4. Provide beige boot on multimode connectors

### **7.2.5.1 Approved Manufacturer's**

1. Corning
2. Ortronics
3. Siemon
4. Systemax

## **7.2.6 Fiber Optic Termination Panels**

A. Rack Mountable in standard EIA 19 inch equipment rack

B. Provide separate panels for multimode and single-mode fiber

### **7.2.6.1 Approved Manufacturer's**

1. Panduit

## **7.2.7 Multi-Pair Copper Riser Cable**

A. Shielded 24 AWG multi-pair copper cables shall be used as the vertical riser cables. The cable shall support voice, data and building service applications. The bending radius and pulling strength requirements of all backbone cables shall be observed during handling and installation. The multi-pair copper cables shall be riser rated and placed in conduit.

B. ARMM Shielded Non-Plenum Riser Cable

1. Shielded non-plenum riser cable shall consist of solid-copper conductors insulated with expanded polyethylene covered by a PVC skin, be conformance tested to meet EIA/TIA 568A for Category 3 cables, be UL® and c (UL®) Listed as CMR. The core shall be overlaid with a corrugated aluminum sheath, which is adhesively bonded to an outer jacket of PVC plastic to form an ALVYN sheath.
2. The PVC sheath shall have improved frictional properties, allowing it to be pulled through conduit without the use of lubricants.
3. The copper riser cable shall meet or exceed the electrical specifications listed below:
  - a. Average DC Resistance: 8.7 ohms/100m, maximum
  - b. Mutual Capacitance @1kHz: 5.25 nF/100m, maximum

### **7.2.7.1 Approved Manufacturer's**

1. Superior Essex

2. General Cable
3. Mohawk/CDT
4. Systimax

#### **7.2.8 Copper Riser Termination Hardware**

- A. Rack Mountable in standard EIA 19 inch equipment rack
- B. Cabling will be terminated Category 5e T568B termination component.

##### **7.2.8.1 Approved Manufacturer's**

1. Panduit

## **7.3 Execution**

### **7.3.1 Installation**

- A. Contractor work force, sub-contractors and material suppliers shall review and comply with all safety, security rules, codes and regulations, applicable to construction site personnel.
- B. Fiber cable shall be installed in one continuous segment. Splicing of fiber cables between telecom rooms is not permitted unless otherwise identified by the City.
- C. Coils of slack cable (1 meter) shall be provided in each fiber termination panel.
- D. Ten meters of cable (maintenance loop) shall be neatly coiled and secured to the wall in each telecom room.
- E. Label all cables as specified in Section 17730.

# 8. Support Structures

## 8.1 General

Support structures are necessary to allow installation of telecommunications wire, cable, connecting hardware, and associated apparatus. These structures comprise components such as equipment racks, cabinets, distribution rings, hangers, J hooks, plywood backboard, cable trays, conduits, slots, sleeves, and their associated hardware.

## 8.2 Pathways

### 8.2.1 General

When installing pathways, it is important to ensure that the route for the pathways are clear of obstructions, such as heating, ventilation, and air conditioning HVAC ducts, large pipes, and structural beams within the building. Whenever fire barriers are penetrated, they shall be firestopped to maintain the fire rating of the barrier.

Determine the entire route of a pathway before installation of supports. The route shall be surveyed prior to installation to ensure that obstacles are avoided. For example, if a wall penetration cannot be established, then the work done to install the support hardware may have to be repeated or modified to get to another location. Penetrations through fire rated walls and floors should be accomplished before installing the hangers, clamps, and trapezes. Once the pathway and cables are installed, firestop the penetrations.

### 8.2.2 Cable Trays

This section addresses the installation of a cable tray within a telecommunications room (TR), equipment room (ER) or entrance facility (EF). However, the principles involved can be applied to installing cable trays between telecommunications spaces (e.g., TR, ER, EF) and as horizontal or backbone pathways.

Cable trays may be installed on single or multiple levels. Corners and changes in horizontal plane are accomplished by using sections of cable tray cut from standard stock and connected together with manufacturer specified hardware. The connecting hardware permits all angles, both vertical and horizontal, to be accommodated over the entire route of the cable tray.

Cable trays shall be wall mounted or supported by the building structure from above using all threaded rods (ATR) and manufacturer specified attachments. ATR shall be installed using properly sized anchors and correct attachment hardware. Select the ATR to support the maximum load for which the cable tray is designed.

Wall mounted support brackets may be used to support cable trays. Where appropriate, wall bracket supports are installed on a wall along the route of the cable tray. The number of brackets and specific spacing interval is dependent upon the rated load the cable tray must support. Supporting attachments shall be made on a cable tray not more than 24 inches from the ends, and at joints between two sections. Additional supports are also required every 5 ft thereafter. Anchors to attach the brackets shall be sized to support the rated load of the cable tray.

Installation of a mesh cable tray is accomplished by using light hand tools, power drills, and an offset blade bolt cutter. Unlike traditional cable trays, this system can be formed to adjust to changes in elevation and horizontal direction without the need for application specific adapters. Corners and changes in horizontal level are accomplished by selective cutting of the mesh in the cable tray at specific points using bolt cutters and connecting the points cut together by means of manufacturer specified attachment hardware.

Cable retaining posts are available in 6 to 12 inch lengths to allow additional cables to be installed to a depth exceeding that of the cable tray. Without these devices the cable would not be confined by the edges of the cable tray and may fall from the tray. The load rating of the cable tray and support elements shall not be exceeded by the addition of cables to this pathway.

#### **8.2.2.1 Installation Practices**

A cable tray is installed from one wall to the opposite wall in a telecommunications room using angled wall supports to secure the cable tray at each end, and by wall bracket supports in the middle. When installing cable trays, maintain a minimum of 12 inches above the tray and 3 inches between the tray and the ceiling tile.

#### **8.2.3 Distribution Rings and Spools (mushrooms)**

Distribution rings and half-distribution-rings are used to support small bundles of cables as they route from one termination point on the plywood backboard to another. However, they should not be substituted for a cable tray. Spools are typically used for cross-connect routing.

Distribution-rings are available in many sizes, shapes, materials, and colors.

Spools are constructed of plastic and contain a center-mounted screw for attachment to plywood backboards. They are also available with threaded bolts for installation on equipment racks.

#### **8.2.4 Conduits**

##### **8.2.4.1 General**

Conduit installations should be designed to be parallel or perpendicular to permanent walls of the building. When installing conduits in a ceiling, a minimum of 3 inch vertical clearance is required above the ceiling tiles. The As-Built drawings should indicate the location of each conduit and where they terminate in the room.

Conduit runs tying buildings together shall be buried at a depth of 36 inches and a minimum of one 4 inch conduit placed in trench (the actual conduit count will be determined by ITSD). This conduit shall be packed with four 1 inch inner ducts each being a different color. There shall be 4 inches of flowable fill on top of the conduit and a caution marker tape placed in the trench 10 inches below the finished grade. A metallic wire is to be placed in the 4 inch conduit to provide a means of locating the pathway at a later date.

#### 8.2.4.2 Segment Limits

No one conduit segment shall be more than 100 ft in length with no more than two 90 degree bends allowed in one segment. Exceeding these limits increases the coefficient of friction in the cable pulling operation and can damage the cable by possibly stretching or changing the cable geometry.

#### 8.2.4.3 Elbows and Bends

Factory-manufactured bends (sweeps) are recommended for conduit installation, especially for conduits over 1.25 inch trade size. Reducing the recommended bending radius can result in cable damage during the cable pulling process. Field manufactured bends, if not accurately fabricated, may turn out elliptical (oval) in shape rather than round. This elliptical shape is generally caused by the action of the tools used to bend the conduit. See Table 1 for minimum bend radii of conduits.

**Table 1.**

<b>If the conduit has an internal diameter of ...</b>	<b>The bend radius shall be at least ...</b>
2 inches or less Diameter	6 times the internal conduit diameter
More than 2 inches diameter	10 times the internal conduit diameter

If needed, flexible metal conduit may be used. However, the length of flexible metal conduit should be less than 20 ft a run. Flexible metal conduit runs exceeding 6 ft shall be bonded by an equipment bonding conductor.

#### 8.2.4.4 Conduit Terminations

Conduits that enter a room (e.g., telecommunications room) should be terminated on the wall to enable orderly routing of the cables to termination hardware within the room. Conduit ends should be positioned adjacent to a corner of the backboard (in the case of a single piece of plywood) or in the corner of the room (where multiple sheets of plywood are installed around the perimeter walls of the room). If conduits cannot be located in these positions, cable trays should be used to route the cables from one location in the room to another.

When entering from below grade or between floors, the conduits shall extend 1 inch to 3 inches above the floor slab or building structure, which will prevent cleaning solvents or other fluids

from flowing into the conduit. Conduits shall be reamed and installed with bushings, which will mitigate sheath damage when pulling cable(s).

Where several large backbone cables are passing vertically through the room, a vertical cable tray or other suitable vertical attachment should be appropriately positioned to support the cables. When a cable tray is used, the cables should be secured to the cable tray in an orderly fashion to ensure that they are properly supported and the entire weight of the cable is equally distributed over several cable tray rung supports.

#### **8.2.4.5 Bonding and Grounding Conduits**

Conduits shall be bonded to the equipment grounding system. Conduits shall be bonded to either the telecommunications main grounding busbar (TMGB) or to a telecommunications grounding busbar (TGB) where present.

Grounding bushings are typically installed on the end of the conduit. For electrical metallic tubing (EMT), a set-screw fitting is placed on the end of the conduit and the grounding bushing screwed on to the fitting and tightened using the appropriate tool. On intermediate metal conduit (IMC) and rigid metal conduit (RMC), a grounding bushing may be screwed onto the threaded end of the conduit and tightened until secure. A threadless grounding bushing, installed with set screws, is also available which can provide an alternate means for locating the ground lug.

In a TR or ER, each conduit can be attached to the channel stock with a conduit strap. A single conduit in each run of channel stock can be equipped with a grounding bushing. The entire section of channel stock can effectively be grounded using a single bushing and ground wire. An alternative method is to install a grounding connection onto the channel stock and then route the ground conductor to the nearest TMGB or TGB.

Where a small number of conduits are installed, a grounding bushing should be installed at the end of each conduit for the attachment of a ground wire, which connects to the TMGB or TGB. Conduits in close proximity to each other can be bonded together and one of them will be bonded to the TMGB or TGB.

#### **8.2.4.6 Securing Conduit**

Conduits shall be secured to prevent movement.

Throughout the conduit route, cross bracing may be used to stabilize the conduit(s), which will mitigate lateral movement during cable pulling operations. Stabilizing the conduits can be accomplished by the use of conduit straps, channel stock, or ATR placed at opposing angles (180 degrees opposite from each other). The same anchoring mechanisms can be used to secure the straps and cross braces as used to hang the conduits from the building structure.

When terminating conduits at a plywood backboard (e.g., in a telecommunications room), they should be secured to the top of the plywood backboard or just above the backboard when entering from overhead. Securing and terminating conduits above the plywood backboard allows for full usage of the plywood backboard for termination and routing of cabling. Channel stock may be used to attach the conduits to the room wall.

#### **8.2.4.7 Stub-up/Stub-out Conduits**

These terms imply that a section of conduit is used to provide a pathway in a vertical and then horizontal direction from a point of termination. While similar in many ways, they are significantly different from an installation perspective. Stub-up/stub-out conduits are generally not grounded.

#### **8.2.4.8 Stub-up Installation**

Stub-ups are usually single sections of 3/4" metal conduit or unless otherwise identified by the City. They typically originate at a 4 inch square box installed in drywall or paneling. The stub-up continues vertically through the wall cavity where it penetrates the wall cap and stubs up into the ceiling area. It terminates at that point and is equipped with a conduit bushing and a pull string. Sometimes the stub-up is equipped with a 90-degree bend that is turned back into the room, especially when installed in fire- or smoke-rated walls.

#### **8.2.4.9 Stub-out Installation**

Stub-outs are short runs of 3/4" metal conduit or unless otherwise identified by the City.. They typically originate at a 4 inch square box installed in drywall or paneling. The stub-out continues vertically through the wall cavity, where it penetrates the wall cap, and continues into the ceiling area. In a typical installation, the conduit continues through the ceiling area and into an adjacent hallway. The conduit may terminate as it exits the wall into the hallway, or it may continue to another type of supporting structure such as a cable tray or ladder rack. It terminates at that point and is equipped with a conduit bushing and a pull string.

#### **8.2.5 Supports**

There are many types of supports available for conduit installation. Three examples of conduit supports are pipe hangers, trapeze, and a one piece conduit hanger.

A pipe hanger is a pear shaped device that is attached to an ATR. It is suspended from the building structure by an anchor or beam clamp and a section of ATR. Anchors are installed in the concrete structure of the above floor. When concrete is not available and steel trusses are installed in the building, beam clamps can be used to support the ATR and hanger. The selection of anchors and beam clamps should be determined by the load of the conduit and cable to be supported. The ATR is attached to the pipe hanger with nuts and lock washers. The assembly is then capable of supporting the conduit that is installed through the pipe hanger.

Another type of conduit support is a trapeze. This is a device that is made by using two ATRs and a section of channel stock. The ATR is suspended from the building structure and attached to each end of the channel stock using appropriate nuts and washers. The conduits are then attached to the channel stock with conduit straps and locked in place.

A third type of conduit support is a one piece conduit hanger. This is a device that is manufactured in such a way that the compression bolt is part of the hanger itself and, when loosened, it will not come off the hanger. This type of hanger can be mounted directly to the building structure, to red iron, or to a specialized hanger mount.

### **8.2.6 Surface Raceway**

Surface raceway is available in both metallic and nonmetallic versions. When installing surface raceway, follow manufacturer's instructions. Metallic surface raceway shall be bonded to the equipment grounding system.

## **8.3 Spaces**

### **8.3.1 Plywood**

Plywood backboards are recommended to be installed around the entire perimeter of rooms (e.g., telecommunications room). This will allow cables to be installed and terminated around the walls of the room, now or in the future. It may also facilitate attaching cables that pass through vertically to rooms above or below.

A minimum of two walls should be covered with rigidly fixed 0.75 inch A-C grade plywood, preferably void free, 8 ft high, capable of supporting attached equipment. The plywood should be installed with the "A" grade side exposed and the "C" grade side against the building wall or structure. Plywood should be either fire-rated or covered with two coats of fire retardant paint as required by the City Of San Antonio, ITSD.

Plywood sheets used for backboards should be installed with the longest dimension reaching from the floor level up toward the ceiling to its 8 ft height. Plywood shall be installed in such a manner that there is no separation between adjacent sheets. When installing plywood in a corner, the plywood backboard shall be installed to form a smooth, tight, gap-free corner.

The plywood backboard shall be secured on top of existing drywall or to wall studs of the room. When installing plywood on drywall, which has already been installed on metal studs, verify the load rating of the wall before installing the plywood. If the load rating will permit this type of installation, use a minimum of 0.25 inch toggle bolts (butterfly bolts) to ensure the stability of the installation. Toggle bolts should be installed at approximately 24 inch spacing around the entire perimeter of the plywood sheet. The toggle bolts should be installed 2 inches from the edges of the sheet of plywood on 24 inch centers.

### **8.3.2 Equipment Racks**

Equipment racks should meet the requirements of ANSI/EIA-310-D. Equipment racks shall be secured to the building structure and should be accessible from the front and rear. Typical spacing is 36 inches in front and back of the rack, and 30 inches on the sides. Where equipment racks are separated from a wall, cable trays should be installed from the wall to the top of the equipment racks. This provides a pathway for cables to be routed between equipment racks. Transitions between cable trays and equipment racks shall be equipped with a means that

ensures minimum cable bend radii is maintained. All racks shall be bonded to the TGB or TMGB using a minimum 6 AWG copper conductor.

Cables should be routed on the rear sides of the rack using cable management accessories attached to the rear of the rack's vertical channels or in cable management channels on the sides of the rack.

### **8.3.3 Floor Mounted Cabinets**

Ensure that the floor-mounted cabinets will fit the footprint allocated for them prior to installation. If there is a question regarding the space allocated, refer to design drawings or contact the designer for further clarification.

Cable access to floor mounted cabinets is normally provided by knockouts (pre-punched holes) in the cabinet side, top, or bottom. Cable trays and ladder racks provide a means of routing cables to the cabinet. Transitions between cable trays and cabinets shall be equipped with a means that ensures minimum cable bend radii are maintained. Verify the cable installation methods specified by the manufacturer prior to attempting to install cabinets.

When floor mounted cabinets are used, the grounding and bonding instructions shall be followed.

### **8.3.4 Wall-mounted Equipment Racks and Cabinets**

When wall-mounted equipment racks and cabinets are required, the grounding and bonding instructions shall be followed.

## **8.4 Bonding Infrastructure**

### **8.4.1 General**

Grounding and bonding are terms that are used to define the practice of connecting all metallic components of a system together to a main building ground electrode, for the purposes of reducing or eliminating the differences of potential between all of the utilities inside of the building structure. See ANSI /J-STD 607 A.

### **8.4.2 Bonding Conductor**

Ground conductors and a ground bus shall be installed so that they are not obstructed by cable trays, cables, or terminating hardware. Ground wires and bonding conductors should always be installed in the straightest and shortest route between the origination and termination point. A minimum bend radius shall not be less than eight times the conductor diameter. A sharp bend may interfere with the effectiveness of the grounding system since it will modify the characteristics of the grounding path.

### **8.4.3 Summary**

This section includes the Telecommunications Grounding and Bonding component of the Premise Distribution System for the City Of San Antonio.

Section Includes but is not limited to:

1. Telecommunications Bonding Backbone (TBB)
2. Telecommunications Main Grounding Busbar (TMGB)
3. Telecommunications Grounding Busbar (TGB)
4. Warning Labels

Product Data:

1. Manufacturer's catalog data and applicable special fabrication and installation details.
2. Installation, terminating and splicing procedures.
3. Instructions for handling and storage.
4. Dimensions and weights.
5. Conformance Certificate and Quality Assurance Release: Signed by QAP Manager (Section 01450). Specifically identify products and include purchase order number, supplements, and item number where applicable. Indicate that requirements are met and identify approved deviations.

### **8.4.4 Design Requirements**

A. Design grounding system following NEC Article No. 250 – Grounding, IEEE 142-1991-Recommended Practice for Grounding of Industrial and Commercial Power Systems.

B. Design Standards:

1. Completely protect above-surface structures and equipment.
2. Calculate system on the basis of existing soil resistivity.
3. If cathodic protection for underground sewer pipe is installed (see applicable Division 2 Sections), ensure the pipe is not connected to the general grounding system, either directly through grounding cable or indirectly through grounded electrical devices connected to the pipe. Electrically isolate electrical devices from sewer pipe.

### **8.4.5 Products**

#### **8.4.5.1 Communications Grounding Conductors**

Insulated copper American Wire Gauge (AWG) wire following ASTM-B3, ASTM-B8 and ASTM-B33, of following sizes:

1. Main ground source feed from the building ground system to the Telecommunications Main Ground Busbar (TGMB): No. 3/0 AWG green insulated standard copper ground wire.
2. Telecommunications Bonding Backbone (TBB), from the TMGB to the Telecommunications Ground Busbars (TGB): No. 3/0 AWG green insulated stranded copper ground wire.
3. TGB to equipment cabinets and racks, conduits, cable raceways, etc.: No. 6 AWG green insulated stranded copper ground wire.

#### **8.4.5.2 Grounding Connectors**

Connectors shall be a copper alloy material and two-hole compression lug type at all connecting ends.

#### **8.4.5.3 Ground Rods**

A minimum of ten feet long, 3/4-inch diameter, copper-clad steel.

#### **8.4.5.4 Telecommunications Main Grounding Busbar**

The TMGB, located in the main distribution facility (MDF), shall comply with the following:

1. The TMGB shall be a predrilled copper busbar with standard NEMA bolt hole sizing and spacing for the type of connectors to be used.
2. The TMGB shall be sized for the immediate requirements and allow for growth. The minimum dimensions shall be ¼ inch thick by 4 inches wide by 23 inches long.
3. The TMGB shall be electrotin plated for reduced contact resistance.
4. The TMGB shall have pre-drilled holes, which shall support a minimum of two tiers of eight No. 6 AWG copper two-hole compression lugs.
5. The TMGB shall be an ASTM-B187-C11000 Copper bar, Cooper B-Line part number SB-476 or submitted and owner-approved equivalent, and shall be suitable for use with two-hole compression-type copper lugs.
6. The TMGB shall comply with ANSI/EIA/TIA 607.

#### **8.4.5.5 Telecommunications Grounding Busbar**

Each TGB, located in the intermediate distribution facilities (IDFs), shall comply with the following:

1. The TGB shall be a predrilled copper busbar with standard NEMA bolthole sizing and spacing for the type of connectors to be used.

2. The TGB shall be sized for the immediate requirements and allow for growth. The minimum dimensions shall be ¼ inch thick by 4 inches wide by 23 inches long.
3. The busbar should be electrotin plated for reduced contact resistance.
4. The TMGB shall have pre-drilled holes, which shall support a minimum of two tiers of eight No. 6 AWG two-hole copper compression lugs.
5. The TMGB shall be an ASTM-B187-C11000 Copper bar, Cooper B-Line part number SB-476 or submitted and owner-approved equivalent, and shall be suitable for use with two-hole compression-type copper lugs.
6. The TMGB shall comply with ANSI/EIA/TIA 607.

#### **8.4.5.6 Equipment cabinet and rack ground busbar**

1. Provide and install a ground busbar in all relay racks, frame racks and equipment cabinets to be used as an equipment grounding bus.
2. The busbar shall be for equal-flange (channel) 19-inch rack width and shall include ground bar, splice plate and #12-24 mounting hardware.
3. The minimum dimensions shall be ¾ inch in width by 3/16 inch in thickness.
4. The busbar shall have pre-drilled holes, which shall support a minimum of eight No. 6 AWG two-hole copper compression lugs.
5. Unless specified otherwise, the busbar shall be Cooper B-Line part number SB-579-03 or submitted and owner-approved equivalent, and shall be suitable for use with two-hole compression-type copper lugs.
6. The busbar shall comply with ANSI/EIA/TIA 607.

#### **8.4.6 System Requirements**

##### **8.4.6.1 General**

1. All conductor wire, busbars and conduit shall be UL listed.
2. The communications ground system shall be separate and independent from all power grounding.
3. Power grounding and/or bonding shall not be allowed to interfere or provide any back feed or be a conductor to the separate communications ground system source or to any communications bonded materials or equipment.

#### **8.4.6.2 TMGB**

1. The main ground source feed to the TMGB in the MDF shall be a separate and independent feed from the main building ground system.
2. The main ground source feed shall be a No. 3/0 AWG green insulated stranded copper ground wire from the building or counterpoise ground system to the TMGB in the MDF.
3. The No. 3/0 AWG green insulated stranded copper ground wire shall be installed in a two-inch metallic conduit.
4. The No. 3/0 AWG green insulated stranded copper ground wire connections shall be exothermically welded at connecting ends.
  - a. The first weld shall be at the main building electrical entrance facility grounding electrode conductor ground system end.
  - b. The second weld shall be at the TMGB.

#### **8.4.6.3 TBB and TGB**

1. The TBB originates at the TMGB and shall be extended from the TMGB to each TGB within the MDF and throughout the building using the telecommunications backbone pathways, to the TGB(s) in each IDF. The minimum TBB conductor size shall be a No. 3/0 AWG green insulated stranded copper ground wire. The TBB shall be installed in a two-inch metallic conduit.
2. The communications ground system shall be a separate ground system and be completely independent and isolated from all power grounding.
3. The TBB No. 3/0 AWG green insulated stranded copper ground wire connections shall be exothermically welded at connecting ends.
  - a. The first weld shall be at the TMGB.
  - b. The second weld shall be at TGB.

#### **8.4.6.4 Equipment cabinets and racks**

1. All cabinets and racks shall be provided with a separate communications ground, consisting of a No. 6 AWG green insulated stranded copper ground wire, from the nearest TGB in the room and home run to each cabinet or rack ground busbar. Unless otherwise noted in the drawings, do not loop ground wire.
2. All ground raceways within cabinets and racks shall be an insulated one-inch metallic flexible raceway and shall include the proper transition electrical metallic tubing (EMT) fittings.
3. All ground raceways and fitting connections shall be bonded

#### **8.4.7 Execution**

#### **8.4.7.1 Examination**

A. Field Measurements: Verify dimensions in areas of installation by field measurements before fabrication and indicate measurements on shop drawings. Coordinate fabrication schedule with construction progress to avoid delaying the work.

B. Established Dimensions: Where field measurements cannot be made without delaying the work, establish dimensions and proceed with fabricating units without field measurements. Coordinate supports, adjacent construction, and fixture locations to ensure actual dimensions correspond to established dimensions.

#### **8.4.7.2 Preparation**

A. Contractor's on-site RCDD supervisor shall review, approve and stamp all shop drawings, coordination drawings and record drawings.

B. Complete site preparation and soil compaction before trenching and driving ground rods for underground grid.

C. Verify exact location of stub-up points for grounding of equipment, fences and building or steel structures.

D. Copper and copper alloy connections should be cleaned prior to connection.

#### **8.4.8 Installation**

##### **8.4.8.1 General**

1. Bonding conductors shall be routed with minimum bends or changes in direction and should be made directly to the points being bonded.
2. Bonding connections should be made by using:
  - a. Compression copper lugs. Use listed hardware that has been laboratory tested to eliminate most field problems.
  - b. Exothermic welding (see NEC Article 250) within the ground electrode system, for parts of a grounding system that are subject to corrosion or that must carry high currents reliably, or for locations that require minimum maintenance.
3. Drive rods vertically, leaving top 18 inches exposed above finished grade. Exothermic-weld below-grade grounding connections, except at ground rods. Install additional ground rods as required to pass resistance test.
4. Make connections to dry surfaces only. Remove paint, rust, oxides, scales, grease and dirt from surfaces before making connection. Sand clean a one square inch area, drill, tap, and bolt conductor and connector to sanded area. Ensure proper conductivity.
5. The No. 3/0 AWG insulated ground wire weld ends shall have a minimum amount of wire exposure from the conduit to each weld and a minimum amount of insulation removed at weld.

6. The No. 6 AWG insulated ground wire connecting ends shall have a minimum amount of insulation removed at ground lug.

7. Do not connect ground wire in power cable assemblies to the communications ground system.

#### **8.4.8.2 TMGB**

1. Install the TMGB in the MDF as shown in the communications drawing set. The TMGB should be located so that the bonding conductor is as short and straight as possible. Maintain clearances required by applicable electrical codes.

2. The TMGB shall be attached to the wall studs with tapping screws with the bottom of the busbar 84 inches above finished floor (AFF).

3. The TMGB shall be offset from the wall two inches and shall include support brackets and insulators.

4. Connect the TMGB to the main building electrical entrance facility ground system and telecommunications primary protectors.

#### **5. TMGB Weld Requirements**

a. The No. 3/0 AWG ground wire weld from the main source shall not exceed one inch from one end of the TMGB busbar.

b. One additional weld shall not exceed one inch from the opposite end of the TMGB busbar.

c. Two or more additional welds shall not exceed the one-inch spacing from the welds toward the center of the busbar.

d. The No. 3/0 AWG insulated ground wire weld ends shall have a minimum amount of wire exposure from the conduit to the weld and a minimum amount of insulation removed at weld.

#### **8.4.8.3 TGB**

1. Install the TGBs in the IDFs. The TGB should also be located so that the bonding conductor is as short and straight as possible. Maintain clearances required by applicable electrical codes.

2. The TGB shall be attached to the wall studs with tapping screws with the bottom of the busbar 84 inches above finished floor (AFF).

3. The TGB shall be offset from the wall two inches and shall include support brackets and insulators.

#### **4. TGB Weld Requirements**

a. The No. 3/0 AWG ground wire weld from the TMGB shall not exceed one inch from one end of the TGB busbar.

b. One additional weld shall not exceed one inch from the opposite end of the TGB busbar.

- c. Two or more additional welds shall not exceed the one-inch spacing from the end welds toward the center of the busbar.
- d. The No. 3/0 AWG insulated ground wire weld ends shall have a minimum amount of wire exposure from the conduit to the weld and a minimum amount of insulation removed at weld.

#### **8.4.8.4 Equipment Cabinets and Racks**

1. The busbar shall be installed at the base and back of each cabinet and rack.
2. Each cabinet and rack shall be provided with a No. 6 AWG insulated ground wire home run to the TGB, except as noted:
  - a. In a cabinet or rack bay, provide a home run ground wire to the first cabinet or rack from the wall.
  - b. From the first cabinet or rack, the No. 6 AWG insulated ground wire may be looped from cabinet frame to cabinet frame (or rack to rack, where applicable), connecting to each cabinet frame (or rack) ground busbar, not to exceed four adjacent cabinets (or racks).
  - c. Do not loop from rack to cabinet.
3. Each cabinet or rack bay against the wall shall be bottom/side ground feeds from the wall.
  - a. Wall ground feeds/raceways to racks shall not be exposed on the walls.
  - b. Exception: Some cabinet or rack bays will require the ground to be fed from the ceiling raceway. Refer to drawings for details.
4. All ground raceways within each cabinet (or on each rack, where applicable) or cabinet base and adjacent ganged cabinet base shall be an insulated metallic flex type raceway and shall not interfere with equipment mounting framing or equipment mounting brackets.
5. Each ground feed shall provide proper installation allowances and penetration depths to provide conversion fittings from solid metallic to insulated metallic flex conduit raceways.
6. To bond each cabinet and rack to ground, sand clean a one square inch area, drill, tap, and bolt conductor and connector to sanded area.

#### **8.4.8.5 Cable Tray/Runway, Cable Raceway and Support Systems Grounding:**

1. Provide communications cable tray and cable runway systems with a communications isolated ground from the nearest TGB.
2. Provide and install No. 6 AWG insulated ground wire to one end of each cable tray/runway system and home run to nearest TGB.
3. Communications cable tray/runway that is located in the same room as the TMGB shall be connected to the TMGB.
4. Provide grounding path between cable tray/runway sections with grounding strap, Cooper B-Line part number SB-669-1 or submitted and owner-approved equivalent.

5. For electrically non-continuous conduits which contain only a grounding conductor, bond the conduit and conductor together at both ends to ground.

6. Bond conduit ends to nearest TGB with grounding bushings or ground clamps.

#### **8.4.8.6 Shielded Backbone Cable**

Terminate and bond shield to the nearest TGB or TMGB at both ends, following manufacturer's guidelines.

#### **8.4.8.7 Unshielded Backbone Cable**

1. Route a No. 6 AWG copper ground wire along each backbone cable route.

2. Bond each end at the nearest TGB or TMGB in the area that the associated cables are terminated.

#### **8.4.8.8 Other**

Provide and install No. 6 AWG green insulated stranded copper ground wire home run to nearest TGB from each of the following:

1. All conductive ducts.

2. All communications conductive equipment.

3. All communications conductive hardware.

#### **8.4.8.9 Install permanent warning labels adjacent to each TMGB and TGB.**

1. Install label as close as possible to busbar.

2. Label shall contain following information:

## **8.5 Installing Cable Support Systems**

### **8.5.1 General**

Cable support systems typically installed for telecommunications include the following:

- Cable trays and associated hardware
- Ladder racks and associated hardware
- Enclosed cable pathways and associated hardware
- Plywood backboards, straps, distribution-rings, hangers, fasteners, and J-hooks
- Conduits and associated hardware

Support systems provide a pathway for the cable, thus minimizing stress that could cause damage to the copper pairs or glass strands inside a cable sheath. The following installation steps are general in nature and additional steps may be required, depending on the size, quantity, and load rating of the individual supporting structures.

Since these support systems are used to support both backbone cables and horizontal cables, they are found in most areas of the buildings. It may be the case that other utilities (i.e., HVAC, plumbing, electrical) or structural obstructions will require that the cable support system change elevation and direction. Careful planning is important to minimize changes in direction which can be costly from a material as well as labor perspective.

#### **8.5.1.1 Steps—Install Cable Support Systems**

1) Obtain blueprint/specifications/designer's documents.

Determine the size, type, and quantity of pathways to be installed.

Determine the proposed route of the pathways between rooms and from rooms to work areas.

Identify any obstructions along the proposed route and determine how to overcome them.

If it is necessary to pass through any walls, be prepared to make the required penetration—concrete, concrete block, drywall, or other wall construction.

When installing cables in a suspended ceiling without permanent pathways, avoid cable paths that introduce obstacles.

Identify the plan to support cable in suspended ceilings and what type of hardware will be installed.

2) Verify load capacity of the cable support system. Verify by:

Reviewing the telecommunications designer's documents.

Determining the weight of individual types and sizes of cable to be installed.

Identifying the building structure to ensure the attachment of the support system is designed for that structure.

3) Verify the load capacity of existing cable support structures.

Where existing supports are to be used, visually examine them to determine if they are firmly attached, not worn or broken, and are capable of bearing the extra weight.

4) Verify cable support installation accessibility. Examine the following:

Area where the building beams and other structural elements are located.

Area where the concrete floor slab above is accessible and usable for installing anchors or other cable supports directly to them.

Paths in all directions from the point of observation to confirm if the pathway is clear for cable supports.

5) Metallic cable separation.

Maintain specified distances from possible sources of EMI exceeding 5 kVA (*see Table 2*).

For safety purposes, keep power cables physically separated from telecommunications cables.

For branch circuits of 5 kVA or less no additional separation should be necessary.

*NOTE—Optical fiber is immune to the effects of EMI.*

**Table 2. Minimum separation distances from possible sources of EMI exceeding 5 kVa**

Condition	Minimum Separation Distance
Unshielded power lines of electrical equipment in proximity to open or nonmetal pathways.	610 mm (24 inches)
Unshielded power lines or electrical equipment in proximity to a grounded metal conduit pathway	300 mm (12 inches)
Power lines enclosed in a grounded metal conduit (or equivalent shielding) in proximity to a grounded metal conduit pathway	150 mm (6 inches)
Electrical motors and transformers	1200 mm (47 inches)

6) Verify material and tool availability.

Before beginning the installation of a cable support system, be sure that the required materials, hand tools, and power tools are available. This should also include safety tools such as safety glasses and, where required, hardhats.

7) Mount distribution-rings.

Review the designer's drawing and specifications to determine exact placement, quantity, size, and type of distribution-rings.

Install the distribution-rings, working from the top left side of the plywood backboard to the bottom right side of the plywood backboard.

Measure the location of the first distribution ring to be installed according to the designer's documents.

Position the distribution-ring on the backboard and install the screws to secure the distribution ring.

8) Installing J-hooks.

Determine the J-hook size required in each cable path and lay them out along the cable route, an average of 5 ft apart.

Identify the location of the first J hook to be installed.

Position the J-hook at its designated location and mark the holes for the anchors.

Pre-drill the holes and install the anchors. Depending on the type of structure, (i.e., a masonry structure will require one type of anchor while metal structures or drywall will require others).

Install the anchors.

Reposition the J-hook at the anchor(s).

Install the screw(s) through the hole(s) in the J-hook and into the anchor, securing the J-hook to the anchor(s).

Install the remaining J-hooks using the same procedures.

9) Install cable tray systems.

The process of installing a cable tray or trays is manufacturer specific, due to the many different sizes, types, and configurations. Consult the manufacturer's specifications and installation guidelines prior to installing these pathways.

Trays can be installed parallel to and against a wall or can be suspended from the building structure using ATR. They can also be supported using channel stock or manufacturer specific supports.

10) Install conduits.

See subclause 2.2.4.2, subclause 2.2.4.3 and TIA 569-B for maximum length of conduit and bends between pull points and pull box sizing.

All metal conduits installed for the placement of telecommunications cable will be bonded to the equipment grounding system.

All conduits shall have a pull string installed.

11) Conduit hangers.

Conduits are suspended from the building structure using a variety of hangers. These hangers are available in many sizes and types depending on the type of conduit and method used to install the hangers. Refer to the manufacturer's specifications for use of the type and size for the conduit hanger to be installed.

12) Installing wireway.

Wireways are different from cable trays in that they are completely enclosed pathways. They usually feature a hinged cover or one which snaps in place. They are available in a number of sizes and shapes, depending on the manufacturer. As with cable trays, the installation methodology is directly related to the manufacturer's guidelines. All metallic wireways installed for the placement of telecommunications cable shall be bonded to the equipment grounding system.

13) Pathway documentation.

The pathway shall be identified on the construction drawings and physically marked with a label that identifies it and states its origin and terminus. (See ANSI/TIA 606-A.)

14) General housekeeping.

It is important to clean up after a work operation when installing pathways. In general, equipment of sufficient size is required to install pathways and the materials are bulkier – thereby taking up space in the hallways and passageways of the building. This causes congestion and, if left in place, can impact the work efforts of others.

Hangers, their associated hardware, anchors, screws, and other materials can present a safety hazard to workers and should be stored during work operations and upon completion of the day's activities. If a work area cannot be cleaned, safety cones and barricades should be placed to prevent accidental intrusion into the work area by others until the work is complete and the area is cleaned.

# 9. Pulling Cable

## 9.1 General

Backbone cable is typically a high pair count copper cable (25- to 2400-pair), or high strand count optical fiber cable. Horizontal cable is typically 4-pair balanced twisted-pair with a performance level of category 3, 5e, or 6, or 2- to 6-strand optical fiber. For indoor optical fiber cable, the preferred color-coding scheme and written nomenclature for premises cable jackets are specified in ANSI/TIA 598-C (see Table 3). An example of the nomenclature used is that of a 12-fiber cable containing eight 50/125  $\mu\text{m}$  and four 62.5/125  $\mu\text{m}$  fibers. The nomenclature for such a cable may include “12 Fiber — 8 x 50/125, 4 x 62.5/125” in the jacket print statement. For ultraviolet (UV) stabilized indoor/outdoor cable, the preferred color is black. The City Of San Antonio standard for multimode optical fiber cable is 62.5/125  $\mu\text{m}$  or unless otherwise identified by the City..

When cable is received at the job site, the cable length should be verified to ensure the cable will reach between the end points. Inspect both ends of the cable to verify the footage markings on the outer jacket and compute the actual length of the jacket. The cable shall be identified, labeled, and the as built updated to reflect the work operation. As built plans shall be provided to the owner as a permanent record.

**Table 3. Preferred color coding scheme for premises cable jackets (ANSI/TIA 598-C)**

Fiber Type	Non-Military Applications	Military Applications	Suggested Print Nomenclature
Multimode (50/125)	Orange	Orange	50/125
Multimode (50/125) (850 nm laser optimized)	Aqua		850 LO 50/125
Multimode (62.5/125)	Orange	Slate	62.5/125
Multimode (100/140)	Orange	Green	100/140
Single-mode	Yellow	Yellow	SM/NZDS SM
Polarization Maintaining Single-mode	Blue		Undefined

## 9.2 Cable Pulling Setup

### 9.2.1 Overview

A good cable pulling setup means all materials are in place so the cables can be handled properly and safely. A cabling contractor may need specialized equipment capable of holding large reels. Smaller equipment, such as cable trees, may be used to handle the many reels of cable containing low pair count cable.

The pathway of a cable shall be free of sharp bends and turns. The manufacturer’s recommended pulling tension and minimum bend radius (while under tension) shall not be exceeded. The use of cable lubricants can significantly reduce friction and speed cable

installation (e.g., within a conduit). A lubricant should be selected based on cable manufacturer's recommendations.

When large, high pair count copper cables are installed in conduits, the pulling of the cable places significant tension on the conduit. A winch is generally employed in this high pair count placing operation. Sometimes the winch is anchored to the building or attached directly to the conduit. This tension causes swinging and swaying of the conduit and its hangers. Excessive movement of the conduit can cause the hangers to loosen and possibly come free. If this happens, the conduit and its cable could fall to the floor resulting in damage to the cable, the building, or injury to individuals.

Communication with co-workers is essential in every cable pull. Each co-worker should be prepared to alert the person pulling the cable, to ensure the cable is traversing the route smoothly without twisting, kinking, or getting bound up.

## **9.2.2 Pulling Horizontal Cable in Conduit**

### **9.2.2.1 Overview**

Horizontal cable is installed between the telecommunications room and work area outlets. Cable shall not be bent or kinked. Should the cable be damaged during installation, do not attempt to repair it but replace the entire cable.

It is recommended that cables and their reels be labeled prior to pulling cable into place. It is easier to identify and label the cables before they are pulled through the conduit.

### **9.2.3 Pulling Horizontal Cable in Open Ceiling**

The procedure for cable installation in open ceilings is different from that in conduits. Cables shall be supported by cable tray, conduits, or J-hooks.

### **9.2.4 Pulling Backbone in Vertical Pathway—From Top Down**

It is generally easier to install cable from the top down rather than from the bottom up because gravity helps with the pull. When pulling cable from top down, a reel brake may be needed. A reel brake is a mechanical device used to stop or slow a freewheeling reel, thus keeping it from unreeling too fast due to gravity. Pulleys may be needed to handle the cable from the reel location to the point where it will be lowered to lower floors. In the room where the cable will enter the vertical pathway, a bullwheel may be required to ensure that the jacket is not damaged as it enters the pathway.

### **9.2.5 Pulling Backbone in Vertical Pathway—From Bottom Up**

When pulling cable from bottom up, a winch may be needed. Cable sheaves may be necessary to handle the cable from the reel location to the point where it will be pulled up to upper floors. In the room where the cable will enter the vertical pathway, a bullwheel may be required to ensure that the jacket is not damaged as it enters the pathway. Installers should be located on each floor through which the cable will pass as well as the top floor where it will terminate.

These individuals shall be equipped with tools to perform critical tasks during the placing operation.

### **9.2.6 Pulling Backbone—Horizontal**

Backbone cable is used to interconnect telecommunications rooms on the same floor.

Cable sheaves may be necessary to handle the cable from the reel location to the point where it will be pulled. In the room where the cable will enter the horizontal pathway, a bullwheel may be required to ensure that the jacket is not damaged as it enters the pathway.

### **9.2.7 Cable Pulling Precautions**

To verify receipt of undamaged cable, while the cable is still on the reel, the installer should verify that there is continuity with the cable still on the reel. For copper cable, continuity can be verified by use of an ohm-meter.

For optical fiber cable, continuity can be verified by shining a light source into the fiber strands or using a power meter or optical time domain reflectometer (OTDR), prior to installation.

Innerduct may be placed inside conduit, through sleeves, or placed in cable trays to facilitate cable pulls, cable removal, and to relax pulling tension exerted on the cable.

# 10. Firestopping

## 10.1 General

A **firestop** is a passive fire protection system of various components used to seal openings and joints in fire-resistance rated wall and/or floor assemblies, based on fire testing and certification listings. Re-establishing the integrity of fire rated walls, floors, and ceilings is an essential part of a cabling installation.

Penetrations through fire-rated assemblies made during the installation and any holes created by the removal of existing penetrants shall be sealed to the original rating of the fire rated architectural structures and assemblies using manufacturer approved methods in accordance with local code requirements. See ANSI/TIA 569-B, Annex A for information regarding firestops.

The term firestop refers to the installation of “qualified/listed” firestop materials in holes made through fire-rated floors, walls, or ceilings for the penetration of pipes, cables, or other construction/building, service/utility items. Firestop products are used to restore the opening to the original fire-rated integrity. Most common requirements are for 1, 2, or 3 hours. In rare instances, a 4-6 hour rating will be provided.

There are two basic types of penetrations:

- Through penetration is a hole made in a fire-rated wall or floor to run pipes, cables, or any type of building service, completely through from one side of the fire barrier to the other side.
- Membrane penetration is a hole in one side of a fire-rated wall or floor for a single surface-barrier penetration. (i.e., an electrical outlet/switch box).

Therefore, the installer:

- Cannot substitute products that are not part of the qualified assembly.
- Cannot add more of a product to get a higher rating.
- Can be held personally responsible for improperly firestopping or not firestopping.
- Can contact the manufacturers to get written assistance for situations not covered in their installation practices for qualified assemblies.
- Shall follow manufacturer requirements for conduit fill ratios.

There are ten basic types of firestop products:

- Mechanical systems
- Mortar/compounds
- Composite sheets
- Collar/devices
- Blankets
- Caulks/sealants

- Putty
- Wrap strips
- Pillows/bags
- Sprays

Mechanical systems consist of manufactured elastomeric components pre-sized and shaped to fit around standard cables, tubes, and conduits. These products are made of several substances which resemble rubber and are flexible. These systems use mechanical pressure to hold the elastomeric components in place and to provide a tight seal around the penetrating devices. Whether or not frames are included, some means of applying compression to the modules is required.

Non-mechanical firestop systems are generally pliable. These include products such as putties, caulks, blankets, silicone foam, pillows, and other types of materials that can be molded to fit into an opening to seal it.

When firestopping conduits, fill ratios provided by the manufacturer shall not be exceeded. Failure to comply with these requirements will prevent the application of the proper amount of firestop being installed around the penetrating cables and not allow the intumescent properties of the firestop material to be realized. This will lead to failure of the firestop.

## 10.2 Typical Installations

### 10.2.1 Sealing a Floor Penetration With Putty

The following describes an example of installing a putty seal from one side of a floor penetration.

- 1) Tear off a small portion of the putty.

NOTE: Use a drop cloth or other cover to protect the floor surface from the putty and insulation material.

- 2) Use the putty to build a bottom in the penetration, according to the manufacturer's instructions.
- 3) Fill the penetration with ceramic fiber or rock wool fill, stopping far enough from the upper rim to allow for a top layer of putty at the manufacturer's recommended thickness.
- 4) Use the putty to build a top on the penetration, according to the manufacturer's instructions

### 10.2.2 Sealing an Outlet Box With Putty

To seal an outlet box, follow the steps below.

- 1) Press a pad of putty into place, covering one side of the outlet box. Ensure that the pad overlaps at the top, bottom, and sides

- 2) Press a second pad of putty, if needed, into place on the other side of the box
- 3) Press the seams together to join the two pads.

### **10.2.3 Steps—Restore Penetrations (general)**

- 1) Firestop conduits, pipes, and innerducts in brick, concrete block, or concrete wall.

The requirements for firestopping are variable and are directly dependent upon:

- Fire-barrier construction
- Material passing through the firewall
- Hourly rating required
- Opening size
- Installing the materials according to manufacturer tested methods

- 2) Firestop floor penetrations.

Sealing of cored or sleeved openings in floor slabs containing pipes, cables, or innerducts requires knowledge of floor thickness, floor construction, hourly fire rating required, opening size, annular space, sleeves, and materials selection.

- 3) Firestopping drywall.

- Requirements for firestopping are variable and are directly dependent upon hourly rating, opening size, annular space, sleeves, along with type and number of penetrants.
- Drywall penetrations are typically required to have firestopping installed symmetrically on both sides of the wall to restore fire rating.

- 4) Firestopping all applicable penetrations.

- Inspect all cable runs for any openings made through fire-rated walls as part of structured cabling system.
- If sleeves have been used, be sure to firestop the wall penetrations on both sides and each end of the sleeve itself.

- 5) Firestop cable tray.

Penetration by a cable tray in a firewall is only permitted by The City of San Antonio with prior approval. Generally the tray is placed against each side of the firewall and a number of appropriately sized sleeves are installed for cables to pass through.

If a cable tray penetrates directly through firewalls, specific manufactured seal systems should be obtained.

# 11. Cable Terminations

## 11.1 General

Cable termination involves the organizing of cables by destination, forming and dressing cables, labeling, and creating a connection with a copper or fiber conductor.

## 11.2 Pre-Termination Functions

Cable termination preparation not only improves the quality of the job but also decreases the amount of time required for termination.

The performance of pre-termination functions involves organizing the cable by destination. Cable to be terminated should be placed at the point of termination and shall be identified to ensure it is terminated in the designated position. Cable connection is not complete until all terminations are identified and labeled.

Alien crosstalk is associated with copper balanced twisted-pair cabling and an issue of which the installer must be aware. This issue can be mitigated by allowing cables to have a more natural lay rather than forming tight bundles and allowing cables to be run next-and-parallel to each other. While forming and dressing the cable at the point of termination may be visually pleasing, doing so for longer distances, such as within a cable tray, may lead to alien crosstalk performance issues. Separation of balanced UTP cables should follow the guidance of ANSI/TIA 568-B.1-10 and TIA/TSB 155.

## 11.3 Copper IDC Termination

### 11.3.1 General

Copper terminations are used for balanced twisted pair cabling and the use of insulation displacement contact (IDC) is recommended. When terminating balanced twisted-pair copper cable:

- Remove only as much cable jacket as is required for termination and trimming.
- Follow the manufacturer's instructions for mounting, termination, and cable management.
- Minimize the amount of untwisting in a pair as a result of termination to connecting hardware. For untwisting cabling, maintain pair twists as close as possible to the termination point. The amount of untwisting will not exceed:
  - 1 inch for category 3 cables.
  - 0.5 inch for category 5e and higher cables.

NOTE—This requirement is intended to minimize untwisting of cable pairs and the separation of conductors within a pair. It is not intended as a twist specification for cable of jumper construction.

The T568A and the optional T568B wiring schemes are recognized for use with horizontal copper cable. Only one of the wiring schemes will be used in a project.

### 11.3.2 Steps—IDC Termination

- 1) Using a sheath removal tool, remove the cable sheath in accordance with the termination equipment manufacturer's specifications.
- 2) Binder groups are found in 50 pair cables and above. Separate and identify binder groups. See Table 4.
- 3) Limit the untwisting of cable pairs to the minimum length required to make the termination. The untwist of cable pairs shall not exceed 0.5 inch.
- 4) Terminate cable according to connecting hardware manufacturer's recommendations.

**Table 4. Color-code chart up to 600 pair**

Pair Number	Tip	Ring	Binder Group	Pair Count
1	White	Blue	White-blue	001-025
2	White	Orange	White-orange	026-050
3	White	Green	White-green	051-075
4	White	Brown	White-brown	076-100
5	White	Slate	White-slate	101-125
6	Red	Blue	Red-blue	126-150
7	Red	Orange	Orange-red	151-175
8	Red	Green	Red-green	176-200
9	Red	Brown	Red-brown	201-225
10	Red	Slate	Red-slate	226-250
11	Black	Blue	Black-blue	251-275
12	Black	Orange	Black-orange	276-300
13	Black	Green	Black-green	301-325
14	Black	Brown	Black-brown	326-350
15	Black	Slate	Black-slate	351-375
16	Yellow	Blue	Yellow-blue	376-400
17	Yellow	Orange	Yellow-orange	401-425
18	Yellow	Green	Yellow-green	426-450
19	Yellow	Brown	Yellow-brown	451-475
20	Yellow	Slate	Yellow-slate	476-500
21	Violet	Blue	Violet-blue	501-525
22	Violet	Orange	Violet-orange	526-550
23	Violet	Green	Violet-green	551-575
24	Violet	Brown	Violet-brown	576-600
25	Violet	Slate		

## 11.4 Fiber Termination

In telecommunications, there are two specific types of optical fiber used: multimode and single-mode. Each specific type of fiber has its own characteristics. Multimode optical fiber has an outside diameter of 125  $\mu\text{m}$ . The glass core of the fiber, which carries the optical signal, has a diameter of 50  $\mu\text{m}$  or 62.5  $\mu\text{m}$ . Single mode optical fiber has an outside diameter of 125  $\mu\text{m}$ . The glass core of the fiber, which carries the optical signal, has a diameter of 8-9  $\mu\text{m}$ . The optical fibers within cables are color coded as shown in Table 5. The City Of San Antonio standard for multimode optical fiber cable is 62.5/125  $\mu\text{m}$  or unless otherwise identified by the City..

Optical fiber cores shall be precisely aligned between connecting cables to ensure that the maximum transfer of light energy is obtained. Termination procedures for optical connectors in the field vary by manufacturer. Listed below are some of the various methods:

- Heat-cured termination: A fiber connector termination method requiring field polishing using an adhesive that requires heat for curing.
- Crimp termination: A fiber connector termination method requiring field polishing using a mechanical means to secure the fiber.
- Anaerobic termination: A fiber connector termination method requiring field polishing using an adhesive and catalyst that cures very quickly.
- Pre-polished connectors: A fiber connector termination method using mechanical means to hold the fiber against a preinstalled and factory polished fiber sub in the ferrule of the connector.

The City Of San Antonio standard for optical fiber termination is fusion spliced cable assemblies (pigtails). See section 8.6.

### **Warning:**

- 1) Care should be used when handling fibers so as not to break them, or to handle them in such a way that they could penetrate your skin. Safely dispose of fiber shards per the City's practice.
- 2) **Never look into the ends of an optical fiber as the transmitted light may be invisible and cause eye damage.**

**Table 5. Optical fiber color code chart (ANSI/TIA-598-C)**

Fiber No.	Color	Fiber No.	Color	Fiber No.	Color
1	Blue	13	Blue/Black Tracer	25	Blue/Double Black Tracer
2	Orange	14	Orange/Black Tracer	26	Orange/Double Black Tracer
3	Green	15	Green/Black Tracer	27	Green/Double Black Tracer
4	Brown	16	Brown/Black Tracer	28	Brown/Double Black Tracer
5	Slate	17	Slate/Black Tracer	29	Slate/Double Black Tracer
6	White	18	White/Black Tracer	30	White/Double Black Tracer
7	Red	19	Red/Black Tracer	31	Red/Double Black Tracer
8	Black	20	Black/Yellow Tracer	32	Black/Double Yellow Tracer
9	Yellow	21	Yellow/Black Tracer	33	Yellow/Double Black Tracer
10	Violet	22	Violet/ Black Tracer	34	Violet/Double Black Tracer
11	Rose	23	Rose/Black Tracer	35	Rose/Double Black Tracer

12	Aqua	24	Aqua/Black Tracer	36	Aqua/Double Black Tracer
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## 11.5 Copper Cable Splicing

Copper cable splicing is allowed only in backbone cable—never for horizontal cable which extends between the telecommunications room and the work area.

Two common modular (groups of pairs) splicing techniques are in-line and foldback. Foldback splicing is the preferred method, where practicable.

With the in-line splicing method, wire is placed in a straight-across arrangement and provides for little wire slack. The in-line method is not designed to be rearranged and should receive minimum handling.

The foldback splicing method allows the conductors to be folded into the splice which in turn provides for maintenance, rearrangement, and transfer of the conductors. The foldback method typically requires more cable be stored within the splice and could increase the size of the needed splice closure.

The splice connecting hardware shall be selected by the designer to meet the application requirements. Follow the equipment manufacturer's installation guidelines.

The installer should pay particular attention to:

- Check cable shield for presence of unsafe voltages.
- Bond cable shields across the splice before splicing.
- Bond cable shields to ground.

## 11.6 Optical Fiber Cable Splicing

There are two major categories of field-splicing methods for optical fibers—fusion and mechanical. Both single-fiber and multiple-fiber (typically 6- or 12-fibers) splicing methods are available.

Only fibers with the same core and cladding dimensions and similar performance characteristics (bandwidth) shall be spliced (e.g., 50  $\mu\text{m}$  core to 50  $\mu\text{m}$  core; 2000 MHz/km to 2000 MHz/km).

The splice hardware shall be selected by the designer to meet the application requirements. Follow the equipment manufacturer's installation guidelines.

## 12. Installation Verification

Installation conformance is performed through a systematic method that ensures the installation has been completed in accordance with industry standards and the terms and conditions of the installation contract. Visual inspection and documentation are required for proof of proper installation conformance (See ANSI/TIA 606-A for administrative requirements such as labeling).

Performance test documentation of the installed cabling shall be provided to the City Of San Antonio per contract requirements, or, in lieu of contract requirements, in the format delivered by the certification test instrument and Adobe PDF format. Certification of the cabling in the City buildings determines whether the cabling meets expected ANSI/TIA 568-B Series performance (e.g., category 5e, category 6).

Field testing of installed cabling shall be performed in accordance with Appendix A.

# 13. Safety And Cautions For Fiber Optic Installation

## 13.1 Fiber Optic Installation Safety

### 13.1.1 General

Safety in fiber optic installations includes avoiding exposure to invisible light radiation carried in the fiber; proper disposal of fiber scraps produced in cable handling and termination; and safe handling hazardous chemicals used in termination, splicing or cleaning.

The following are examples of safety precautions that should be followed during fiber optic cable installations. This is not a comprehensive list of OSHA regulations governing fiber optic installations.

### 13.1.2 Eye Protection

- a) Always wear safety glasses with side shields. Always ensure that safety eyewear complies with relevant requirements including OSHA.
- b) After handling fiber, wash hands thoroughly before touching eyes or contact lenses.
- c) Never look directly into the end of any optical fiber unless it is certain that no light is present in the fiber. The light used for signal transmission in fiber optics is generally invisible to the human eye but may operate at power levels that can be harmful to the eye. Inspection microscopes can concentrate the light in the fiber and increase the danger. Use an optical power meter to verify that no light is present in the fiber.
- d) When using an optical tracer or continuity checker, look at the fiber from an angle at least 12 inches away from the eye to determine if the visible light is present.

### 13.1.3 Protection From Fiber Scraps

Small scraps of bare fiber produced as part of the termination and splicing process shall be disposed of properly in a safe container and marked according to local regulations, as it may be considered hazardous waste.

- a) Do not drop fiber scraps on the floor where they will stick in carpets or shoes and be carried elsewhere. Place them in a marked container or stick them to double-sided adhesive tape on the work surface.

- b) Thoroughly clean the work area when finished. Do not use compressed air to clean off the work area. Sweep all scraps into a disposal container.
- c) Do not eat, drink or smoke near the working area. Fiber particles can be harmful if ingested.
- d) Wash hands well after working with fibers.
- e) Carefully inspect clothing for fiber scraps when finished working with fiber.

#### **13.1.4 Other Safety Issues**

- a) Work only in well-ventilated areas. Confined spaces, such as equipment vaults, manholes can contain toxic or explosive gases or insufficient air to sustain life.
- b) Materials and chemicals used in installation processes may be hazardous. Request Material Safety Data Sheets (MSDS ) on all chemicals used.
- c) Fusion splicers create an electric arc. Ensure that no flammable vapors and/or liquids are present. Do not use in confined spaces as defined by OSHA.

## **13.2 Cleanliness**

The small size of optical fibers makes them very sensitive to dust and dirt. Maintain the highest standards of cleanliness when working with fiber to optimize its performance.

#### **13.2.1 Guidelines For Cleanliness**

- a) Try to work in clean areas.
- b) Always keep protective dust caps on connectors, mating adapters, patch panels, or test and network equipment.
- c) Do not touch the ends of the connectors.
- d) Use lint-free wipes and pure reagent grade isopropyl alcohol to clean connectors. Other solvents can attack adhesives or leave a residue. Cotton swabs or pads may leave threads behind and are not recommended.
- e) "Canned air" can be used to blow dust out of mating adapters or equipment inputs/outputs.
- f) Test equipment fiber inputs/outputs and test cables should be cleaned periodically.

# 14. Fiber Optic Installation Requirements

## 14.1 General Guidelines

### 14.1.1 Receiving Fiber Optic Cabling and Equipment on Site

Fiber optic equipment and components are subject to damage by improper handling and shall be handled accordingly.

When initially received on the job site all fiber optic components should be carefully inspected for damage and tested for continuity or loss if damage is suspected.

Ensure that all components and parts have been received, match quantities ordered (e.g., fiber optic cable contains the number and type of fiber ordered and is the length ordered), and that any discrepancies or damaged goods are noted and replaced as required.

All equipment and cabling shall be stored in a clean and dry location, protected from harsh environments and extremes of cold and heat.

### 14.1.2 Handling Fiber Optic Cables

Handle reels of fiber optic cable with care. All reels, regardless of size or length, shall have both ends of the cable available for the testing. A fiber tracer or visual fault locator and bare fiber adapters can be used for continuity testing.

Move small, lightweight spools of fiber optic cable by hand. Move larger reels with appropriate lifting equipment or using two or more installers skilled in the moving operation.

Lifting equipment shall only be reels with a matched set of slings or chokers, attached to an appropriately sized piece of pipe inserted into the hole in the center of the reel. Slings and chokers shall never be attached around the spooled area of the reel. The cable reels shall be moved carefully to avoid damage to the cable.

## 14.2 Support Structures

Install support structures for fiber optic cable installations before the installation of the fiber optic cable itself. These structures should follow the guidelines of TIA/EIA 569-A and NECA/BICSI 568-2001.

Allow for future growth in the quantity and size of cables when determining the size of the pathway bend radius requirements.

Do not install a fiber optic cable in a conduit or duct that already contains cabling, regardless of the cable type. Existing or new empty ductwork can be modified to accept several different installations by placing innerduct within it.

## **14.3 Removal of Abandoned Cables**

Unless directed by the City that unused cables are reserved for future use, remove abandoned optical fiber cable (cable that is not terminated at equipment other than a connector and not identified for future use with a tag) as required by the National Electrical Code.

## **14.4 Fire Stopping**

### **14.4.1 General**

All telecommunications firestopping shall comply with applicable codes and standards, including TIA/EIA 569-A- Annex A and NECA/BICSI 568-2001.

All penetrations shall be protected by approved firestops. Fire stopping compounds and devices shall be used whenever a fire separation has been breached by an installation.

In most geographical locals the breaching of a fire separation will require physical monitoring until it has been repaired.

Check with the City Of San Antonio for specific requirements on the project before commencing work.

## **14.5 Grounding and Bonding**

### **14.5.1 General**

Ground systems shall be designed as specified by the NEC and other applicable codes and standards (ANSI/TIA/EIA 607-A, NECA/BICSI-568-2001).

Although most fiber optic cables are not conductive, any metallic hardware used in fiber optic cabling systems (such as wall-mounted termination boxes, racks, and patch panels) shall be grounded.

Conductive cables require proper grounding and bonding for applicable conductors.

# 15. Fiber Optic Cables

## 15.1 Cable Types

Fiber optic cables are available in many types, for different applications. Premises cables are usually tight buffer designs that include jackets rated for flammability. OSP cables are generally loose tube designs with water blocking and may also have an armored jacket.

Some cables are usable for either OSP or premises applications. These include dry-water blocked tight buffered cables that can be used for short outdoor runs and double jacketed asp cables that have a removable outside jacket and an inner jacket that is rated a flame retardant.

### 15.1.1 Cables by Fiber Types

Fiber optic cables may contain multimode fibers, singlemode fibers or a combination of the two, in which case it is referred to as a "hybrid" cable. The type of cable shall be positively identified and, if hybrid, the type of each fiber, since multimode and singlemode fiber are terminated in different manners. See Section 14 for more information on termination.

### 15.1.2 Fiber Optic Cables by Construction Type

#### a) Tight Buffered Cables

Tight buffered fiber optic cable contains fiber with a soft 900-micron diameter coating that protects the fiber and is color-coded for identification. Tight buffered fibers are cabled with strength members (usually aramid fibers) in simplex or zip cord cables for use as patch cords.

Multiple tight buffered fibers may be cabled with aramid fiber strength members and a central stiffener in a cable type called a distribution cable, often used for premises backbones, horizontal runs or general building cabling.

Several simplex cables can be bundled in a single cable called a breakout cable. Simplex, zipcord and breakout cables may be directly terminated for connection to a patch panel or network equipment as the cable provides adequate protection for the fibers.

Fibers in distribution cables are terminated directly, but the lack of protection for the fibers requires they be placed inside patch panels or wall-mounted boxes.

#### b) Loose Tube Cable

Loose tube (also called loose buffer) fiber optic cable consists of one or more protective tubes, each containing one or more fibers with only 250-micron primary coating over the fiber.

Loose-tube cable is primarily used for outside plant installations where low attenuation and high cable pulling strength are required.

Many fibers can be incorporated into the same tube, providing a small-size, high-fiber density construction. The tubes are usually filled with a gel, which prevents water from entering the cable. The fibers in loose tube cables are protected from the outside environment and can be installed with higher pulling tensions than tight-buffered cables.

Fiber in loose tube cables may be spliced directly and placed in appropriate protective enclosures. Fibers in loose tube cables which have only the 250 micron primary coating should be sleeved with a break out kit for protection before termination and placed in patch panels or wall-mounted boxes for protection.

## 15.2 Flammability - Cable Ratings and Markings

All premises cables shall be listed and have flammability ratings per NEC 770.50. Cables without markings should never be installed inside buildings, as they do not comply with the National Electrical Code. Optical cable markings are as follows:

OFN	optical fiber nonconductive
OFC	optical fiber conductive
OFNG or OFCG	general purpose
OFNR or OFCR	riser rated cable for vertical runs
OFNP or OFCP	plenum rated cables for use in air-handling plenums
OFN-LS	low smoke density

## 15.3 Fiber Optic Cable Color Codes

### 15.3.1 Cable Jackets

Colors of cable jackets for identifying indoor fiber optic cable are not standardized. Typical colors are as follows:

#### Premises cables:

Orange or gray	Multimode fiber
Yellow	Singlemode fiber

#### Outside plant cables:

These are typically black to prevent UV radiation damage.

**Some military cables** are color-coded for fiber type:

Orange	50/125 micron
Slate	62.5/125
Green	100/140

Some indoor cables are black or other colors. Refer to manufacturer's datasheets or cable jacket markings to determine the fibers in the cable.

### 15.3.2 Fiber Color Codes

Fiber color codes are specified by TIA/EIA 598-A. In loose tube cables, this color code shall be used for tubes as well as fibers within the tubes and subgroups.

<i>Fiber No.</i>	<i>Color</i>
1	Blue
2	Orange
3	Green
4	Brown
5	Slate
6	White
7	Red
8	Black
9	Yellow
10	Violet
11	Rose
12	Aqua

## 15.4 Installing Fiber Optic Cable

### 15.4.1 General

Fiber optic cable may be installed indoors or outdoors using several different installation processes. Outdoor cable may be direct buried, pulled or blown into conduit or innerduct, or installed aerially between poles. Indoor cables can be installed in raceways, cable trays, placed in hangers, pulled into conduit or innerduct or blown through special ducts with compressed gas. The installation process will depend on the nature of the installation and the type of cable being used.

Installation methods for both wire and optical fiber communications cables are similar. Fiber cable is designed to be pulled with much greater force than copper wire if pulled correctly, but excess stress may harm the fibers, potentially causing eventual failure.

### 15.4.2 Installation Guidelines

a) Follow the cable manufacturer's recommendations. Fiber optic cable is often custom-designed for the installation and the manufacturer may have specific instructions on its installation.

b) Check the cable length to make sure the cable being pulled is long enough for the run to prevent having to splice fiber and provide special protection for the splices.

c) Try to complete the installation in one pull. Prior to any installation, assess the route carefully to determine the methods of installation and obstacles likely to be encountered.

#### **15.4.2.1 Pulling tension**

a) Cable manufacturers install special strength members, usually aramid yarn, for pulling. Fiber optic cable should only be pulled by these strength members. Any other method may put stress on the fibers and harm them.

b) Swivel pulling eyes should be used to attach the pulling rope or tape to the cable to prevent cable twisting during the pull.

c) Cables should not be pulled by the jacket unless it is specifically approved by the cable manufacturers and an approved cable grip is used.

d) Tight buffer cable can be pulled by the jacket in premises applications if a large (~40 cm, 8 in.) spool is used as a pulling mandrel. Wrap the cable around the spool 5 times and hold gently when pulling.

e) Do not exceed the maximum pulling tension rating. Consult the cable manufacturer and suppliers of conduit, innerduct, and cable lubricants for guidelines on tension ratings and lubricant use.

f) On long runs (up to approximately 3 miles or 5 kilometers), use proper lubricants and make sure they are compatible with the cable jacket. If possible, use an automated puller with tension control and/or a breakaway pulling eye. On very long runs (farther than approximately 2.5 miles or 4 kilometers), pull from the middle out to both ends or use an automated fiber puller at intermediate point(s) for a continuous pull.

g) When laying loops of fiber on a surface during a pull, use "figure-8" loops to prevent twisting the cable.

#### **15.4.2.2 Bend Radius**

a) Do not exceed the cable bend radius. Fiber optic cable can be broken when kinked or bent too tightly, especially during pulling.

b) If no specific recommendations are available from the cable manufacturer, the cable should not be pulled over a bend radius smaller than twenty (20) times the cable diameter.

c) After completion of the pull, the cable should not have any bend radius smaller than ten (10) times the cable diameter.

#### **15.4.2.3 Twisting Cable**

a) Do not twist the cable. Twisting the cable can stress the fibers. Tension on the cable and pulling ropes can cause twisting.

- b) Use a swivel pulling eye to connect the pull rope to the cable to prevent pulling tension causing twisting forces on the cable.
- c) Roll the cable off the spool instead of spinning it off the spool end to prevent putting a twist in the cable for every turn on the spool.
- d) When laying cable out for a long pull, use a "figure 8" on the ground to prevent twisting. The figure 8 puts a half twist in on one side of the 8 and takes it out on the other, preventing twists.

#### **15.4.2.4 Vertical Cable Runs**

- a) Drop vertical cables down rather than pulling them up whenever possible.
- b) Support cables at frequent intervals to prevent excess stress on the jacket. Support can be provided by cable ties (tightened snugly, not tightly enough to deform the cable jacket) or Kellems grips.
- c) Use service loops to assist in gripping the cable for support and provide cable for future repairs or rerouting.

## **15.5 Cable Plant Hardware**

All hardware and support structures should follow the recommendations of TIA/EIA 569 and NECA/BICSI 568-2001.

### **15.5.1 Cable Racks, Trays, Conduit and Innerduct**

- a) Outside plant cables can be installed in conduit or innerduct or direct buried, depending on the cable type.
- b) Premises cabling can be installed in cable trays, ladder racks, I-hooks, or other appropriate support structures.
- c) Building cables can be installed directly, but installing them inside plenum-rated innerduct provides extra protection for the fiber cable. Innerduct is bright orange and will provide a good way to identify fiber optic cable and protect it from damage.

### **15.5.2 Fiber Optic Splicing and Termination Hardware**

- a) Breakout kits: The fibers in loose tube cables have only the 250 micron primary buffer coating. Use breakout kits to separate and protect individual fibers in a loose tube cable for termination.
- b) Splice enclosures: For long cable runs outside, splices are necessary to connect lengths of cable. Splices require protection that is provided by a sealed splice closure. Choose closures with adequate space for the number of fibers in the cables and port locations appropriate for the

final mounting. Splice closures can be sealed and buried in the ground, placed in a vault or suspended aerially.

c) Splice panels and patch panels: Terminate or splice distribution cables inside panels or boxes to protect the fibers from damage. Boxes or panels may be rack- or wall-mounted. All should have locks to prevent unauthorized entry.

d) Racks and cabinets: Enclosures for patch panels and splice panels are used to terminate and organize cables. Use appropriate cable management hardware on the racks to route and separate cables to minimize potential for damage and facilitate moves, adds and changes.

e) Take care with all splicing and termination hardware to maintain cable bend radiuses, prevent pinching or kinking of fibers and separate fibers to allow for future restoration, moves or other work.

## **15.6 Use Of Cable Ties**

a) Fiber optic cables, like all communications cables, are sensitive to compressive or crushing loads. Cable ties used with many cables, especially when tightened with an installation tool, are harmful to fiber optic cables, causing attenuation and potential fiber breakage.

b) When used, cable ties should be hand tightened to be snug but loose enough to be moved along the cable by hand. Then the excess length of the tie should be cut off to prevent future tightening.

c) Hook-and-Loop fastener ties are preferred for fiber optic cables, as they cannot apply crush loads sufficient to harm the cable.

# 16. Fiber Optic Termination

## 16.1 General

Fiber optic termination processes vary according to the types of fiber being terminated, the style of connectors or splices used and the termination process appropriate for that connector. Fiber optic cable can be terminated in two ways, using:

- Connectors that mate two fibers to create a temporary joint and/or connect the optical fiber to network equipment.
- Splices which create a permanent joint between two fibers.

The decision whether to use connectors or splices depends on the application. All terminations must be of the right style, installed in a manner that provides low light loss and back reflection and protected against the expected environment, dirt or damage while in use.

## 16.2 Fiber Optic Connectors

### 16.2.1 Choice of Connector

Fiber optic connectors are manufactured in a number of different styles (e.g., ST, SC, LC, MT-RJ) that attach to the fibers in a fiber optic cable by a number of different methods (e.g., epoxy polish, prepolished/splice, etc.)

The connectors used in the cable plant being installed should:

- 1) Be compatible with the fiber optic cabling,
- 2) Be compatible with the equipment intended for use on the cabling
- 3) Provide adequate optical performance (loss and return loss)
- 4) Be compatible with the operating environment (temperature, humidity, etc.) of the installation and
- 5) Be compatible with like style connectors.

All fiber optic connectors used should have a reference FOCIS document (Fiber Optic Connector Intermateability Standard) published by TIA/EIA.

Fiber optic connectors may be field installed by direct attachment to the cable or by splicing preterminated pigtails onto the installed cable. Multimode connectors are generally installed

directly onto fibers in the field while singlemode cables are more likely to be terminated by splicing on preterminated pigtails.

### 16.2.2 Termination Types

Several different types of terminations are available for optical fibers. Follow the manufacturer's directions exactly for the termination process used to insure best connector performance and reliability.

#### a) Adhesive Terminations

Many connectors use epoxies or other adhesives to hold the fiber in the connector. Use only the specified epoxy, as the fiber-to-ferrule bond is critical for low loss and long term reliability.

1. *Epoxy/Polish*: The fiber is glued into the connector with two-part epoxy and the end polished with special polishing film. This method provides the most reliable connection and lowest losses. The epoxy can be allowed to set overnight or cured in a special oven. A "heat gun" should not be used to cure the epoxy as the uneven heat may not cure all the epoxy or may overheat it which will prevent curing.

2. *Hot Melt*: This connector is similar to the epoxy/polish connector but already has the adhesive (a heat set glue) inside the connector. The adhesive is liquefied in an oven before the fiber can be inserted. The fiber is secured when the adhesive cools.

3. *Anaerobic Adhesives*: These connectors use a quick-setting adhesive instead of the epoxy. They may use a single part adhesive or an adhesive and setting agent. Some adhesives do not have the wide temperature range of epoxies, so they should only be used indoors unless otherwise specified.

#### b) Crimp/Polish or Crimp/Cleave Terminations

These connectors use a crimp on the fiber to hold it in the connector ferrule. The fiber can be polished like an adhesive connector or cleaved with a special tool. Insure the crimp is made properly to prevent fiber pistoning (pulling back or pushing forward in the connector ferrule.)

c) *Prepolished/Splice* These connectors have a short stub of fiber already epoxied into the ferrule and polished. Termination requires cleaving a fiber, inserting it into the back of the connector like a splice and crimping. The loss of these connectors will generally be higher than adhesive connectors, since they include a connector loss plus a splice loss in every connector.

To achieve low loss, the fiber must be cleaved properly, which requires a good cleaver and good technique. Insure the crimp is made properly to prevent fiber pistoning (pulling back in the connector ferrule.) The termination process can be monitored with a visual fault locator.

### 16.2.3 Termination Process

Whichever process is used for termination, follow the manufacturer's instructions carefully. Use only adhesives approved by the manufacturer, and employ adhesive curing times in accordance with the manufacturer's instructions.

When special tools are required, use them in the appropriate manner.

Once installation is completed, connectors should be covered with an appropriate dust cap and stored in a safe location for testing or connection to network equipment.

#### **16.2.4 Connector Performance**

Connector performance shall be within industry standard limits as specified in TIA/EIA 568-B.3. Connector performance may be specified by the City at a different value, and if so, those values shall be used for acceptance.

#### **16.2.5 Performance Verification**

Following completed installation and termination, all terminated cables shall be tested. Section 15 provides more detail on testing requirements at the conclusion of installation.

Examine all connectors requiring polishing with a microscope for proper end finish, cracks, scratches or dirt per FOTP-57.

Test all fibers in all cables for loss using an OLTS power meter and source. Test multimode cables using TIA/EIA 526-14 Method B, and singlemode cables using TIA/EIA 526-7 (single mode). Total loss shall be less than the calculated maximum loss for the cable based on appropriate standards or customer specifications.

#### **16.2.6 Fiber Polarization**

In fiber networks, separate fibers are typically used for transmission in each direction, therefore it is necessary to identify the fiber connected to the transmitter and receiver at each end.

Duplex connectors such as the duplex SC or MT-RJ are polarized, that is they are keyed to allow connection in only one orientation. Follow the polarization rules given in TIA/EIA 568-B3, Section 12.2.4.

Simplex connectors should be documented for connections and when allocated to the transceiver of networking equipment, marked for transmit and receive at each end of the link.

## **16.3 Fiber Optic Splices**

### **16.3.1 Types of Splices**

Splices are a permanent joint or connection between two fibers. There are two basic types of splices, fusion and mechanical.

*1. Fusion Splices:* These "weld" the two fibers together usually in an electric arc. Fusion splicers are generally automated and produce splices that have minimal losses. Fusion splicing

should not be performed in a dusty or explosive atmosphere as the electric arc may cause an explosion or fire.

2. *Mechanical Splices:* These align two fibers in a ferrule or v-groove with index-matching gel or adhesive between the fibers to reduce loss and back reflection. Mechanical splices are used for temporary restoration as well as permanent joints.

### **16.3.2 Splice Performance**

Splice performance shall be within industry standard limits as specified in TIA/EIA 568-B.3. If splice performance may be specified by end users at a different value, and if so, those values shall be used for acceptance.

### **16.3.3 Splice Performance Verification**

End-to-end tests of fiber optic cable loss include the losses caused by splices. If the cable loss exceeds the calculated maximum value, or if the customer requires splice loss verification, test the cable with an OTDR to analyze the loss of individual components (fiber, connectors, and splices) in the cable. Test splice loss in both directions and average the measured values to reduce the directional effects of OTDR measurements.

# 17. Testing The Installed Fiber Optic Cable Plant

## 17.1 General

After installation, test each fiber in all fiber optic cables for verification of proper installation. Perform the following tests:

- a) Continuity testing to determine that the fiber routing and/or polarization is correct and documentation is proper.
- b) End-to-end insertion loss using an OLTS power meter and source. Test multimode cables using TIA/EIA 526-14 Method B, and singlemode cables using TIA/EIA 526-7 (single mode). Total loss shall be less than the calculated maximum loss for the cable based on appropriate standards or customer specifications.
- c) Optional OTDR testing may be used to verify cable installation and splice performance. However, OTDR testing shall not be used to determine cable loss.
- d) If the design documentation does not include cable plant length, and this is not recorded during installation, test the length of the fiber using the length feature available on an OTDR, or some OLTSs.
- e) If testing shows variances from expected losses, troubleshoot the problems and correct them.

## 17.2 Continuity Testing

Perform continuity testing of optical fibers using a visual fiber tracer, visual fault locator, or OLTS power meter and source. Trace the fiber from end to end through any interconnections to insure that the path is properly installed, and that polarization and routing are correct and documented.

## 17.3 Insertion Loss

- a) Insertion loss refers to the optical loss of the installed fibers when measured with a test source and power meter (OLTS). Test multimode cables using Teal 526-14 Method B, and singlemode cables using TIA/EIA 526-7 (single mode). See Appendix B.
- b) Test multimode fiber at 850 and 1300 nm, and singlemode fiber at 1310 and 1550 nm, unless otherwise required by other standards or customer requirements.
- c) Test reference test cables to verify quality and clean them often.

d) Cabling intended for use with high speed systems using laser sources may be tested with appropriate laser sources to ensure that tests verify performance with that type of source.

## **17.4 OTDR Testing**

a) The optical time domain reflectometer (OTDR) uses optical radar-like techniques to create a picture of a fiber in an installed fiber optic cable. The picture, called a signature or trace, contains data on the length of the fiber, loss in fiber segments, connectors, splices and loss caused by stress during installation.

b) OTDRs are used to verify the quality of the installation or for troubleshooting. However, OTDR testing shall not be used to determine cable loss.

c) OTDR testing should only be performed by trained personnel, using certified equipment designed for the purpose. The technicians performing the tests should be trained not only in operation of the OTDR equipment, but also in the interpretation of OTDR traces.

d) See Appendix A for more information on OTDR testing.

# 18. Administration, Management, And Documentation For Fiber Optics

## 18.1 Guidelines

- a) Documentation of the fiber optic cable plant is an integral part of the design, installation and maintenance process for the fiber optic network. Documenting the installation properly will facilitate installation, allow better planning for upgrading, simplify testing and future moves, adds and changes.
- b) Documentation of the fiber optic cable plant should follow ANSI/TIA/EIA-606, *Administration Standard for the Telecommunications Infrastructure of Commercial Buildings*.
- c) Fiber optic cables, especially those used for backbone cables, may contain many fibers that connect a number of different links going to several different locations with interconnections at patch panels or splice closures. The fiber optic cable plant should be documented as to the exact path that every fiber in each cable follows, including intermediate connections and every connector type.
- d) Documentation should also include insertion loss data and optional OTDR traces.

# **19. Labels And Labeling**

## **19.1 Visibility and Durability**

The size, color, and contrast of all labels should be selected to ensure that the identifiers are easily read. Labels should be visible during the installation of and normal maintenance of the infrastructure.

Labels should be resistant to the environmental conditions at the point of installation (such as moisture, heat, or ultraviolet light), and should have a design life equal to or greater than that of the labeled component.

## **19.2 Specifications**

Adhesive labels that meet the legibility, defacement and adhesion requirements specified in UL 969 for indoor use shall be provided. Outside plant labels shall meet exposure requirements listed in UL 969 for indoor and outdoor use.

Labels shall have a durable vinyl substrate suitable for wrapping. Labels shall have a white printing area and a clear tail that self-laminates the printer area when wrapped around the cable. Tail shall be of sufficient length to wrap around cable at least one and one-half time.

## **19.3 Mechanical Generation**

All labels shall be printed or generated by a mechanical device.

## **19.4 Approved Manufacturer's**

Any manufacturer that meets the above criteria and specifications and is approved by the City/ITSD shall be considered acceptable unless specifically excluded.

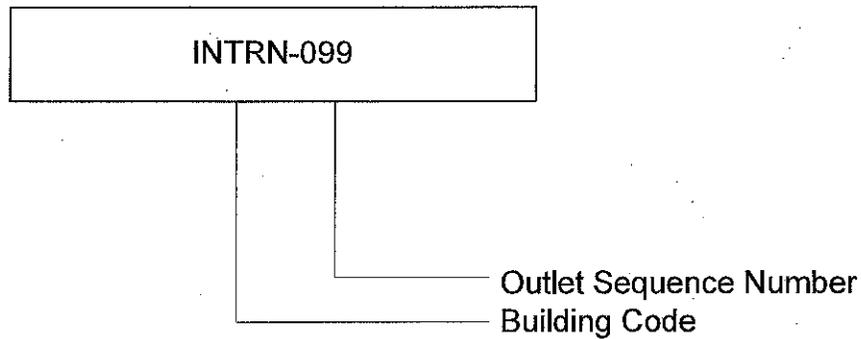
## **19.5 Label scheme**

the City labeling scheme shall be separated into two categories, Legacy and Hierarchical. The Legacy labeling scheme follows a sequential numbering that starts at one (1) and sequences through as many outlets as are installed in a facility. The Hierarchical labeling scheme will be implemented for all new installations where patch panels are being used.

### 19.5.1 Legacy scheme

The Legacy scheme will have as the first characters the the City building code. The building code is a series of alpha numeric characters that indicate the individual building. The second set of characters, separated by a hyphen, will be a series of digits that indicate the outlet number. The numbers will have three places with leading zeros as place holders for numbers less than three digits.

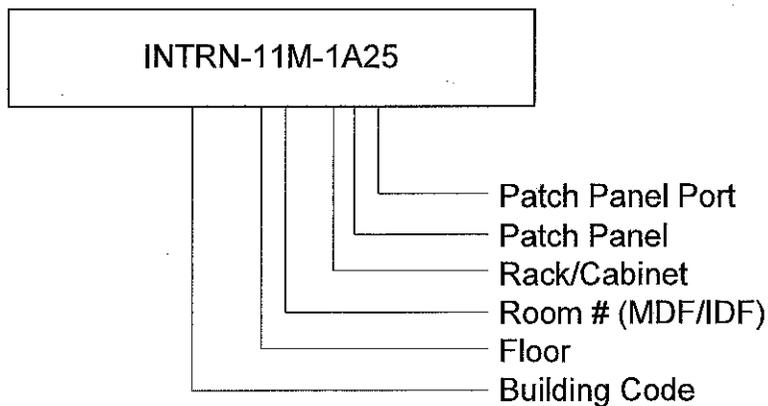
Example:



### 19.5.2 Hierarchical scheme

The Hierarchical scheme will have three series of characters. The first series is the the City building code. The building code is a series of alpha numeric characters that indicate the individual building. The second set of characters, separated by a hyphen, will be the floor number, followed by the room (MDF/IDF) number. The third series indicate the rack, patch panel, and patch panel port number.

Example:



# **Appendix A: Field Test Requirements**

## **A.1 General**

Transmission performance depends on cable characteristics, connecting hardware, patch cords and cross connect wiring, the total number of connections, and the care with which they are installed and maintained.

Field test instruments shall be calibrated and maintained at intervals specified by the manufacturer.

## **A.2 100 Ohm Balanced UTP and ScTP Cabling**

### **A.2.1 Test instruments**

For field testing of the categories of cabling (e.g., categories 3, 5e and 6), test instruments shall meet or exceed the applicable requirements in ANSI/TIA 568-B.1 and ANSI/TIA 568-B.2, including their addenda.

Commercially available certification test instruments specify their Level of performance attainment to ensure that the installed cabling meets the transmission characteristics found in ANSI/TIA 568-B.1 and ANSI/TIA 568-B.2, including their addenda. Fluke DTX 1800, Lantek 6, Wirescope 350 are examples.

### **A.2.2 Performance parameters**

The field tests required for balanced twisted-pair cabling are specified in ANSI/TIA 568-B.1 and ANSI/TIA 568-B.2, including their addenda.

### **A.2.3 Permanent link test configuration**

Installed cabling shall be certified in accordance with the permanent link test configuration unless specified to be tested as a channel.

### **A.2.4 Channel test configuration**

When a channel is specified for testing, it shall be certified in accordance with the channel test configuration.

### **A.2.5 Backbone and other cabling test configuration**

The wire map test for all pairs in backbone and other than horizontal cabling shall be performed and recorded for all segments. Wire map tests include:

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

The length of each backbone cable segment should be measured and recorded.

## A.3 Optical Fiber Cabling

TIA/TSB-140 describes the methods by which optical fiber cabling is to be tested. An optical fiber cabling link may consist of a fiber or concatenated fibers (spliced, cross-connected or interconnected) with a connector or adapter on each end. The fiber type, link length, the number and quality of terminations and splices, cable stresses, and wavelength can all affect attenuation measurements.

Testing conducted on optical fiber cabling should be in accordance with a published standard. As noted in TIA/TSB-140, testing installed optical fiber cabling for attenuation with an OLTS, as described in cabling standards, and verifying the cabling length and polarity constitutes Tier 1 testing. Tier 2 testing, which is optional, includes the Tier 1 tests plus the addition of an optical time domain reflectometer (OTDR) trace. An OTDR trace can be used to characterize the installed fiber link. These traces provide an indication of the uniformity of cable attenuation, and indicate events along the fiber link. These events may be characterized as insertion loss associated with severe bends in a cable run, connector insertion loss and splice insertion loss.

Tier 1 criteria, as specified in TIA/TSB-140, constitutes conformance testing in accordance with this standard. The attenuation measurement result, using the Tier 1 criteria, shall be less than the designed attenuation budget (also known as loss budget) that is based on the number of terminations and cable length.

### A.3.1 Test instruments

OLTS field test instruments for multimode optical fiber shall meet the requirements as specified in ANSI/TIA 526-14-A. OLTS field test instruments for single-mode shall meet the requirements as specified in ANSI/TIA 526-7. Additionally, the light source is to meet the launch requirements of ANSI/TIA 455 78B. This launch condition can be achieved either within the field-test instrument by the manufacturer, or by use of an external mandrel wrap applied to the source test jumper with a Category 1 Coupled Power Ratio (CPR) light source.

*NOTE—Refer to ANSI/TIA 526-14-A for details on measuring source CPR.*

The mandrel-wrap is installed on the transmit test jumper of an OLTS having an overfilled launch when it is used to measure the link loss of multimode fiber links. The installation of the mandrel wrap is performed by wrapping a length of fiber around a smooth round mandrel (rod) for a total of five (5) non-overlapping wraps. A mandrel wrap is never installed on the receive test jumper (optical power meter). Table 6 shows mandrel diameters for typical cabled fiber types.

*NOTE – The mandrel diameters are based on nominal values of 20 mm and 25 mm reduced by the cable diameter and rounded up.*

### **A.3.2 Performance parameters**

OLTS field tests required for optical fiber cabling are as follows:

- Length
- Polarity
- Attenuation

### **A.3.3 Cabling test configuration**

ANSI/TIA 568-B.1 specifies the use of a one jumper reference as described in ANSI/TIA-14-A for multimode cabling and ANSI/TIA 526-7 for single-mode cabling. The following subclauses describe the process for testing multimode fiber cabling with a one jumper reference and the test jumper connected to the source having five non-overlapping wraps of multimode fiber on a mandrel. The procedure is also applicable to single-mode cabling, however, the five non-overlapping wraps of multimode fiber would be replaced with a single 1.2 inch diameter loop of single-mode fiber.

#### **A.3.3.1 Verifying test jumper quality**

To verify that the test jumpers are in acceptable condition, first reference the light source to the optical power meter . Disconnect test jumper (J1) from the power meter (only) and insert a second test jumper (J2) by connecting it to the power meter and to (J1) with a mating adapter and record the measurement. Disconnect both ends of J2, interchange the ends, and reconnect it and record the measurement. The resulting measurements,  $P_{verify}$ , should be within the appropriate connector loss specification. For example, if the connector used is specified at 0.75 dB, the reading on the power meter should be within 0.75 dB of  $P_1$ .

**Table 6. Acceptable mandrel diameters for common multimode cable types (five wraps)**

<b>Fiber Core/Cladding Size (µm)</b>	<b>900 µm Buffered Fiber (mm)</b>	<b>2.0 mm Jacketed Cable (mm)</b>	<b>2.4 mm Jacketed Cable (mm)</b>	<b>3.0 mm Jacketed Cable (mm)</b>
50/125	25	23	23	22
62.5/125	20	18	18	17

#### **A.3.3.2 Steps to measure the cabling optical loss**

The one jumper reference is used to measure the cabling optical loss. The test jumpers shall be 3.3 ft to 16.4 ft in length and shall be verified to ensure they are of acceptable quality. The basic steps taken to measure and calculate multimode cabling attenuation include:

- 1) Verifying test jumper quality (once before testing)
- 2) Setting the reference (once before testing)

3) Measuring link attenuation (each link)

4) Calculating link attenuation (each link)

#### **A.3.3.3 Setting the reference**

When referencing the light source to the power meter, one test jumper (J1) is to be connected between the light source and the power meter and a reference measurement taken ( $P_1$ [dBm]).

*NOTE – To improve the stability of the reference reading and for easier handling, it may be helpful to secure the mandrel to the light source by some means such as a cable tie or tape. Care should be taken to ensure that the fiber jacket is not deformed or damaged when using a cable tie or tape.*

#### **A.3.3.4 Measuring link attenuation**

Connect the end of test jumper (J1) (source end) to one end of the link, and connect an acceptable test jumper (J2) between the other end of the link and the meter (see Figure 28 on next page). The optical power reading is  $P_2$  (dBm).

#### **A.3.3.5 Calculating link attenuation**

Equation 1 is used to determine the fiber cabling link loss (attenuation).

where:

$P_1$  = Reference power measurement

$P_2$  = Cabling test power measurement

$$\text{Attenuation (dB)} = P_1 (\text{dBm}) - P_2 (\text{dBm})$$

# Appendix B: Calculating The Loss Budget For A Fiber Optic Cable Plant

Calculating the loss budget for a fiber optic link determines what is the maximum loss expected in a normal installation. The loss measured by an OLTS (Optical Loss Test Set) should be less than the loss calculated by the following method:

## B.1 Information Necessary:

Length of the link  
Number of connectors Number of splices.

## B.2 Process:

Calculate the loss of the fiber  
Calculate the loss of all connections  
Calculate the loss of all splices  
Add all losses to get the total loss

## B.3 To calculate the fiber loss:

Multiply the length of the fiber times the attenuation at each wavelength:  
850 nm: (length in km) X (3.5 dB/km @ 850 nm) = fiber dB loss @ 850 nm  
1300 nm: (length in km) X (1.5 dB/km @ 1300 nm) = fiber dB loss @ 1300 nm

## B.4 To calculate the connector loss:

Multiple the number of connectors times the maximum allowable loss of 0.75 dB (count the connectors on each end as one each and each mated pair as one connector loss)  
(Number of connectors) X (0.75 dB) = Connector loss in dB

## B.5 To calculate the splice loss:

Multiple the number of splices times the maximum allowable loss of 0.3 dB  
(Number of splices) X (0.3 dB) = Splice loss in dB

## B.6 To calculate the total cable loss, add the losses calculated above:

Total fiber loss in dB = (fiber loss) + (connector loss) + (splice loss)

## **B.7 Interpreting the result:**

Use these numbers as "pass/fail" limits for testing. If the field-measured loss is higher than the calculated value, troubleshoot the installation

# Appendix C: Definitions, Acronyms, Abbreviations, And Units Of Measure

## C.1 Definitions

For the purposes of this document, the following definitions apply:

### **Administration**

The method for labeling, documentation, and usage needed to implement moves, additions, and changes of the telecommunications infrastructure.

### **Alien Crosstalk**

A measure of the unwanted signal coupling between adjacent cabling or components.

### **All-Thread-Rod**

A straight section of round rod stock that has threads installed over its entire length. Also known as a threaded rod (ATR).

American wire gauge:

### **Anchor**

1. A fastening device.
2. In an outside plant environment, a device made up of a single plate or series of flat plates and combined with a rod having a connecting eye.

### **Architectural Structures**

Walls, floors, floor/ceilings, and roof/ceilings that are load bearing.

### **As-built**

The documentation of measurements, location, and quantities of material work performed. May be in the form of marked up documents or other work order forms.

### **Attenuation**

The decrease in magnitude of transmission signal strength between points, expressed as the ratio of output to input. Measured in decibels (dB), usually at a specific frequency for copper or wavelength for optical fiber, the signal strength may be power or voltage.

### **Authority Having Jurisdiction (AHJ)**

The entities responsible for interpretation and enforcement of local building and electrical codes.

### **Backboard**

A panel (e.g., wood, metal) used for mounting connecting hardware and equipment.

**Backbone**

1. A facility (e.g., pathway, cable, conductors) between any of the following spaces: telecommunications rooms, telecommunications enclosures, common telecommunications rooms, floor-serving terminals, entrance facilities, equipment rooms, and common equipment rooms.
2. In a data center, a facility (e.g., pathway, cable, conductors) between any of the following spaces: entrance rooms or spaces, main distribution areas, horizontal distribution areas, and telecommunications rooms.

**Backbone Cable**

See *Backbone* and *Backbone Cabling*.

**Backbone Cabling**

Cable and connecting hardware that provides interconnections between telecommunications rooms, equipment rooms, and entrance facilities. See *backbone*.

**Backbone Pathway**

The portion of the pathway system that permits the placing of backbone cables between the entrance location and all crossconnect points within a building and between buildings.

**Bandwidth**

1. A range of frequencies available for signaling expressed in hertz.
2. The information handling capability of a medium, expressed in units of frequency (hertz).

**Beam Clamp**

A device attached to a building structure to hold cable supports or equipment.

**Bend Radius**

The radius of curvature that a media can bend without signal degradation.

**Binder Group**

One of two or more bound copper pairs or optical fiber strands within a cable.

**Blueprint**

A reproduction of an architectural plan and/or technical drawing that provides details of a construction project or an existing structure.

**Bonding**

The permanent joining of metallic parts to form an electrically conductive path that will ensure electrical continuity and the capacity to conduct safely any current likely to be imposed.

**Bonding Conductor**

A conductor used specifically for the purpose of bonding.

**Bonding Conductor for Telecommunications**

A conductor that interconnects the building's service equipment (power) ground to the telecommunications grounding system.

**Braid**

A group of non-insulated conductors interwoven to surround one or more insulated conductors.

**Bullwheel**

A large wheel used to maintain an arc when feeding large cables into a backbone pathway.

**Bundle**

1. Many individual optical fibers contained within a single jacket or buffer tube. Also, a group of buffered optical fibers distinguished in some fashion from another group in the same cable core.
2. Also used to indicate time and common handling of multiple cables routed together.

**Cabinet**

A container that may enclose connection devices, terminations, apparatus, wiring, and equipment.

**Cable**

An assembly of one or more insulated conductors or optical fibers within an enveloping sheath.

**Cable Run**

A length of installed media, which may include other components along its path.

**Cable Sheath**

A covering over the optical fiber or conductor assembly that may include one or more metallic members, strength members, or jackets.

**Cable Support System**

A combination of conduits, cable trays, support hooks, tie wraps, and any other hardware pieces used in a cabling installation to support cables. Cable support systems keep excess stress off the cables and may provide some mechanical protection to the cables being supported.

**Cable Termination**

The connecting or termination hardware applied to the end of a cable for the purpose of facilitating connection to active or passive transmission equipment.

**Cable Tray**

A rigid structure for supporting, housing and protecting cables or conductors. Usually consists of one-piece solid or ventilated bottom or individual transverse members with two side rails.

**Cable Tree**

A vertical rack with multiple arms for holding small reels of cable.

**Cabling**

A system of cables, cords, and connecting hardware. Equipment/patch cords, and connecting hardware.

**Cabling System**

A specific system of cables, equipment/patch cords, connecting hardware, and other components supplied as a single entity.

**Channel**

1. The end-to-end transmission path connecting interfaces of any two pieces of application-specific equipment. Equipment cords and work area cords are included in the channel.
2. In frequency division multiplexing, a band in the frequency spectrum that is assigned to a specific logical connection.
3. In time division multiplexing, a time that is assigned to a specific logical connection.

**Channel Stock**

A metallic U-shaped bar with or without evenly spaced holes. Often hung in a trapeze configuration for support of pathway systems, such as conduits and cable trays.

**Circuit**

The electrical or optical path used for communications between two devices.

**Code**

A rule intended to ensure safety during the installation and use of materials, components, fixtures, systems, premises, and related subjects. Codes are typically invoked and enforced through government regulation.

**Commercial Building Conduit**

A building, or portion thereof, that is intended for office use.

1. A raceway of circular crosssection.
2. A structure containing one or more ducts.

**Conduit Stub-out**

A short section of conduit that is installed from a receptacle box, usually in a wall, curved into an accessible ceiling space.

**Conduit Stub-up**

A short section of conduit that is installed from a receptacle box, usually in a wall, into an accessible ceiling space directly above the receptacle box.

**Cone**

Safety marker that is used to designate a secure off-limits area for non-workers.

**Connecting Hardware**

A device, or combination of devices, used to connect two cables or cable elements.

**Connector**

A mechanical device used to provide a means for aligning, attaching, and achieving continuity between conductors or optical fibers.

**Consolidation Point**

A location for interconnection between horizontal cables extending from building pathways and horizontal cables extending into furniture pathways.

**Core**

The central, light-carrying part of an optical fiber through which light pulses are transmitted.

**Crimp**

The act of clamping connectors to a cable.

**Cross-connect**

A facility enabling the termination of cable elements and their interconnection or cross-connection.

**Cross-connection**

A connection scheme between cabling runs, subsystems, and equipment using patch cords or jumpers that attach to connecting hardware on each end.

**Crossed Pairs**

An error condition where physical connection of a wire or wires in a pair of wires is made to another wire or wires in yet another pair of wires generally found in the same cable.

**Decibel**

A logarithmic unit for measuring the relative voltage, power (in watts) or strength (in voltage or current) of a signal. A decibel is one tenth of a bel.

**Distribution Ring**

Wire management ring shaped like the letter D for routing and supporting distribution cables and jumpers/patch cables on a backboard.

**Dressing**

Placing cables into a neat and symmetrical pattern for proper alignment and positioning for termination.

**Drywall**

An interior wall construction consisting of gypsum or plasterboard.

**Duct**

1. A single enclosed raceway for conductors, wires, or cables. See also raceway.
2. An enclosure in which air is moved. Generally part of the heating, ventilating, and air-conditioning system of a building.

**Entrance Facility (Telecommunications)**

An entrance to a building for both public and private net work service cables (including antennae) including the entrance point at the building wall and continuing to the entrance room or space.

**Entrance Room (Telecommunications)**

A space in which the joining of campus or building telecommunications backbone facilities takes place.

**Equipment Room (Telecommunications)**

An environmentally controlled centralized space for telecommunications equipment that usually houses a main or intermediate cross-connect.

**Fire Retardant**

Any substance added to delay the start of fire ignition or to slow the spread of flame by the burning material.

**Firestop**

A fire-rated material, device, or assembly of parts installed in a penetration of a fire-rated barrier.

**Firestop System**

A specific listed assembly consisting of the material(s) (firestop penetration seals) that fill the opening in the wall or floor assembly, and around and between any items that penetrate the wall or floor (e.g., cables, cable trays, conduit, ducts, pipes), and any termination devices (e.g., electrical outlet boxes) along with their means of support.

**Firewall**

1. A continuous barrier used to prevent fire spreading from one fire zone or area to another.
2. One or more security mechanisms (hardware and/or software) designed to prevent, detect, suppress, and/or contain unauthorized access to a network.

**Floor Slab**

1. That part of a reinforced concrete floor, which is carried on beams below.
2. A concrete mat poured on subgrade serving as a floor rather than as a structural member.

**Foldback Splicing**

Process of folding back conductors in a splice for future maintenance or rearrangements.

**Ground**

A conducting connection, whether intentional or accidental, between an electrical circuit or equipment and the earth, or to some conducting body that serves in place of earth.

**Ground Electrode**

A conductor, usually a rod, pipe, or plate (or group of such conductors), in direct contact with the earth for the purpose of providing a low-impedance connection to earth.

**Grounded**

Connected to earth or to some conducting body that serves in place of the earth.

**Ground Wire**

See *bonding conductor* and *bonding conductor for telecommunications*

**Grounding System**

A system of hardware and wiring that provides an electrical path from a specified location to an earth ground point.

**Horizontal Cable**

Distribution media that connect the telecommunications outlet/ connector at the work area and the first piece of connecting hardware in the horizontal cross-connect.

**Horizontal Cross-connect**

A group of connectors (e.g., patch panel, punch-down block) that allows equipment and backbone cabling to be cross-connected with patch cords or jumpers. Floor distributor is the international equivalent term for horizontal cross-connect.

**Infrastructure (Telecommunications)**

A collection of those telecommunications components, excluding equipment, that together provide the basic support for the distribution of all information within a building or campus.

**In-line Splice**

A splice in which cable enters one endcap and, after splicing the cable, exits the other endcap of the closure.

**Innerduct**

A non-metallic pathway, usually circular, placed within a larger pathway.

**Insertion Loss**

The signal loss resulting from the insertion of a component, or link, or channel, between a transmitter and receiver (compare “Jumper” and “Mushroom”). See *Attenuation*.

**Insulation**

The dielectric material that physically separates wires and prevents conduction between them.

**Insulation Displacement Contact**

A type of wire termination in which the insulation that is surrounding a conductor is displaced at the connection point without physically stripping the insulation from the conductor and consequently makes a gas-tight connection to the conductor.

**Interconnection**

1. A connection scheme that employs connecting hardware for the direct connection of a cable to another cable without a patch cord or jumper.
2. A type of connection in which single-port equipment connections (e.g., 4-pair and optical fiber connectors) attach to horizontal or backbone cabling by means of patch cord or jumper.

**Intermediate Cross-connect**

The connection point between a backbone cable that extends from the main cross-connect (first-level backbone) and the backbone cable from the horizontal cross-connect (second level backbone).

**Jacket**

The outer layer of a cable. See *Cable Sheath*.

**J-hook**

A supporting device for horizontal cables that is shaped like a “J.” It is attached to some building structures. Horizontal cables are laid in the opening formed by the “J” to provide support for the cables.

**Jumper**

1. An assembly of twisted pairs without connectors, used to join telecommunications circuits/links at the cross-connect.

2. An optical fiber cable with connectors installed on both ends. See *Cable Assembly*.

**Ladder Rack**

A device similar to a cable tray but more closely resembles a single section of a ladder. It is constructed of metal with two sides affixed to horizontal cross members.

**Link**

A transmission path between two points, not including terminal equipment, work area cables, patch cables, and equipment cables. Can be up to 90 m (295 ft) in length for horizontal cabling.

**Local Area Network**

The standard industry term for a network installation that serves a relatively small area (e.g., structured cabling installation serving a building).

**Loss**

Attenuation of a signal, usually measured in dB.

**Main Cross-connect**

The cross-connect normally located in the (main) equipment room for cross-connection and interconnection of entrance cables, first-level backbone cables, and equipment cables.

**Membrane Penetration**

An opening through only one surface or side of a barrier.

**Multimode Optical Fiber**

An optical wave guide that allows many bound modes to propagate.

**Mushroom**

See *Spool*.

**Network**

A series of controllers, all connected via a telecommunications cable.

**Optical Fiber**

A transmission media using a thin filament of glass or plastic to transmit pulse light signals. Its bandwidth is higher than copper and not subject to electromagnetic interference. The optical fiber consists of a central core (glass or plastic) and an outer cladding.

**Optical Fiber Cable**

Cable made up of one or more strands of glass consisting of a central core and outer cladding (optical fibers), strength members, and an outer jacket.

**Outlet Box (Telecommunications)**

A metallic or non-metallic box mounted within a floor, wall, or ceiling and used to hold telecommunications outlets/connectors or transition devices.

**Outlet/Connector (Telecommunications)**

A connecting device in the work area on which horizontal cable or outlet cable terminates.

**Pair**

1. Two insulated wires commonly joined. They can be twisted around each other or mated together as in flat cable.
2. One side circuit (two diametrically facing conductors) in a star quad.

**Pair Count**

1. Indicates how many pairs of grouped conductors are in a cable.
2. The pair identification of cable and pairs serving a location.

**Patch Cord**

A length of cable with connectors on both ends used to join telecommunications circuits/links at the cross-connect.

**Pathway**

1. A sequence of connections that provides the connectivity between devices on a network or between networks on an internetwork.
2. The vertical and horizontal route of the telecommunications cable.
3. A facility for the placement of telecommunications cable.

**Premises**

Building, or set of buildings on common property, that are occupied by a single tenant or landlord.

**Pull**

1. The act of placing cable by pulling.
2. The longitudinal force acting on a pole as a result of horizontal loading.

**Raceway**

Any enclosed channel designed for holding wires or cables.

**Rack**

See *Cable Rack*.

**Reel Brake**

A device used to control the rate of removal of a cable from a cable reel.

**Reversed Pair**

A condition in which the conductors in a pair are terminated in the wrong sequence (i.e., tip connects to ring and ring connects to tip).

**Ring**

A means for identification of one conductor of a pair. Historically associated with the wire connected to the "ring" portion of an operator's telephone plug. See also *Tip*.

**Scope of Work**

A document that provides detailed statements and descriptions of the work content for the project requirements.

**Screened Twisted-pair Cable**

A cable with one or more pairs of twisted copper conductors covered with an overall metallic shield.  
See *Foiled Twisted pair Cable*.

**Sheath**

See *Cable Sheath*.

**Shield**

A metallic layer (e.g., copper braids, metal foils, solid tubing) placed around a conductor or group of conductors.

**Short**

An unintentional low-resistance connection between two conducting materials.

**Single-mode Optical Fiber**

Optical fiber with a relatively small core diameter of 8–9 micron (micrometers) and a cladding diameter of 125 micron; lightwave propagation is restricted to a single path, or mode, in single-mode optical fiber.

**Sleeve**

An opening, usually circular, through the wall, ceiling, or floor to allow the passage of cables.

**Slot**

An opening through a wall, floor, or ceiling usually rectangular, to allow the passage of cables.

**Space (Telecommunications)**

An area used for housing the installation and termination of telecommunications equipment and cable.

**Splice**

1. A joining of conductors in a splice closure, meant to be permanent.
2. A device that joins conducting or transmitting media.

**Splice Case**

A metal or plastic housing with a semi-cylindrical cavity used in identical pairs to clamp around a cable splice to provide a closure.

**Splice Closure**

A device used to protect a splice. See *Splice Case*.

**Split Pair**

Transposition of two conductors of separate pairs.

**Spool**

1. A combination of hardware and software commonly used by print servers to redirect requests destined for a printer.
2. Cylindrical containers of cable. See cable reel.
3. A cylindrical guide, typically used for routing jumpers, cross-connects, and patch cords.

**Standard**

A collection of requirements that encompass properties of components and systems that are intended to ensure an accepted degree of functionality and longevity.

**Stub-out**

See *Conduit Stub-out*.

**Stub-up**

See *Conduit Stub-up*.

**Suspended Ceiling**

A ceiling that creates an area or space between the ceiling material and the building structure above.

**Telecommunications**

Any transmission, emission, and reception of signs, signals, writings, images, and sounds; that is, information of any nature by cable, radio, optical, or other electromagnetic systems.

**Telecommunications Enclosure**

A case or housing for telecommunications equipment, cable terminations, and crossconnect cabling.

**Telecommunications Entrance Facility**

See *Entrance Facility (Telecommunications)*.

**Telecommunications Entrance Room**

See *Entrance Room (Telecommunications)*.

**Telecommunications Equipment Room**

See *Equipment Room (Telecommunications)*.

**Telecommunications Grounding Busbar**

A common point of connection for telecommunications system and equipment bonding to ground; located in the telecommunications room or equipment room.

**Telecommunications Main Grounding Busbar**

A busbar placed in a convenient and accessible location and bonded, by means of the bonding conductor for telecommunications, to the building service equipment (power) ground.

**Telecommunications Outlet**

See *Outlet/Connector (Telecommunications)*.

**Telecommunications Room**

An enclosed space for housing telecommunications equipment, cable terminations, and cross-connects. The room is the recognized cross-connect between the backbone cable and horizontal cabling.

**Tie Wrap**

Plastic or hook and loop strip used for binding and dressing cable.

**Tip**

A means for identification of one conductor of a pair. Historically, associated with the wire connected to the tip portion of an operator's telephone plug. See *Ring*.

**Trapeze**

A support device using threaded rod and channel stock.

**Twisted-pair**

Two individually insulated copper wires physically twisted together to form a balanced pair.

**Twisted-pair Cable**

A multiconductor cable comprising two or more copper conductors twisted in a manner designed to cancel electrical interference. Also called *balanced twisted-pair cable*.

**Underfloor Raceway**

A pathway placed within the floor and from which wires and cables emerge to a specific floor area.

**Unshielded Twisted-pair Cable**

Cable containing one or more pairs of twisted copper without metallic shielding. The entire assembly is covered with an insulating sheath (cable jacket).

**Volt (V)**

A unit of electromotive force or potential difference that will cause a current of one ampere to flow through a resistance of one ohm.

**Wavelength**

The distance between two points in the same phase in consecutive cycles measured in the direction of propagation.

**Wire**

An individually insulated solid or stranded metallic conductor.

**Wireway**

An enclosed pathway for cables.

**Work Area (Workstation)**

A building space where the occupants interact with telecommunications terminal equipment.

**Work Area Outlet**

A connecting device for termination of horizontal media. See also telecommunications outlet/connector.

## C.2 Fiber Optic Definitions

**Attenuation**

The reduction in optical power as it passes along a fiber, usually expressed in decibels per kilometer (db/km). See *optical loss*.

**Attenuation Coefficient**

The *optical* loss of fiber per unit length, expressed in db/km.

**Backscattering**

The scattering of light in a fiber back toward the source, used to make OTDR (Optical Time Domain Reflectometer) measurements.

**Bandwidth**

The range of signal frequencies or bit rates within which a fiber optic component, link, or network will operate.

**Bending or Microbending Loss**

Loss in fiber caused by stress on the fiber bent around a restrictive radius. Most fiber optic cables are specified for a radius of 10 times the cable diameter unloaded or 20 times the cable diameter under pulling tension.

**Buffer**

A protective plastic coating applied directly to the optical fiber. Also called *primary coating*.

**Cable**

One or more fibers enclosed in protective coverings and strength members.

**Cable Plant**

The combination of fiber optic cable sections, connectors and splices forming the optical path between two terminal devices.

**Cladding**

The lower refractive index optical cladding over the core of the fiber that “traps” light back into the core.

**Composite Cable**

A cable containing both optical fibers and electrical conductors.

**Connector**

A device that provides a demountable connection between two fibers or a fiber and an active device.

**Continuity Tester**

A visible light source used to confirm continuity and trace fibers.

**Core**

The center of the optical fiber through which light is transmitted.

**Decibel (dB)**

A unit of measurement of optical power that indicates relative power on a logarithmic scale.  $dB=10 \log$  (power ration).

**Dispersion**

The spreading of a pulse in an optical wave-guide that affects bandwidth. May be caused by modal or chromatic effects.

**End Finish**

The quality of the end surface of a fiber prepared for splicing or terminated in a connector, tested by visual inspection in a microscope.

**Ferrule**

A precision tube, which holds a fiber in alignment for interconnection or termination. A ferrule may be part of a connector or mechanical splice.

**Fiber Optics**

Light transmission through flexible transmissive fibers for communications or lighting.

**Fiber Tracer**

An instrument that couples visible light into the fiber to allow visual checking of continuity and tracing for correct connections.

**Fresnel Reflection**

Light reflected from the cleaved or polished end of a fiber caused by the difference of refractive indices of air and glass. Also called *Back Reflection* or *Optical Return Loss*.

**Fusion Splicer**

A precision instrument that joins two fibers together by melting and fusing them, typically with an electric arc.

**Graded Index Fiber**

A type of multimode fiber, which uses a graded profile of refractive index in the core material to correct for modal dispersion.

**Hybrid Cable**

An optical cable containing both singlemode and multimode fibers.

**Index Matching Fluid Or Gel**

A fluid or gel with a refractive index similar to the fiber used to match the materials at the ends of two fibers to reduce loss and back reflection.

**Insertion Loss**

The loss caused by the insertion of a component such as a splice or connector in an optical fiber. Also refers to the loss of a cable or cable plant when tested with an optical loss test set.

**Jacket**

The protective outer coating of the cable.

**Lambda ( $\lambda$ )**

Greek letter used as a symbol for wavelength.

**Launch Cable**

A high quality fiber optic reference jumper cable used for loss testing, attached to a source and calibrated for output power.

**Link, Fiber Optic**

A combination of transmitter, receiver and fiber optic cable capable of transmitting data.

**Loss Budget**

The estimated amount of power lost in the link.

**Loss Margin**

The additional amount of loss that can be tolerated in a link. Also the difference between the loss acceptable to the networking equipment and the actual loss of the link.

**Mechanical Splice**

A permanent joint between two fibers made with a mechanical alignment device that usually contains index matching gel or adhesive.

**Microscope, Fiber Optic Inspection**

A microscope used to inspect the end surface of a connector for flaws or contamination, or a fiber for cleaves quality.

**Multimode Fiber**

A fiber with core diameter much larger than the wavelength of light transmitted. It allows many modes (rays) of light to propagate.

**Optical Fiber**

An optical waveguide comprised of a light carrying core, surrounding cladding which traps light in the core and the primary coating.

**Optical Loss**

The amount of optical power lost as light is transmitted through fiber, splices, couplers, etc.

**Optical Loss Test Set (OLTS)**

Tester comprised of fiber optic power meter and test source used to test the loss of components or cable plants.

**Optical Power**

The amount of radiant energy per unit time, expressed in linear units or watts or on a logarithmic scale in dBm (where  $dB=10 \log (\text{power}/1 \text{ mW})$ ,  $0 \text{ db}=1 \text{ mw}$ ).

**Optical Time Domain Reflectometer (OTDR)**

An instrument that uses backscattered light to find faults in optical fiber and to infer loss for troubleshooting.

**Overfilled Launch**

A condition for launching light into the fiber where the incoming light has a spot size and NA larger than acceptance cone of the fiber, thereby filling all modes in the fiber.

**Pigtail**

A short length of fiber attached to a fiber optic component such as a connector, laser, or coupler. Pigtails with connectors can be spliced onto cables as an alternative to direct termination.

**Power Budget**

For network equipment, the difference (in db) between the transmitted optical power (in dbm) and the receiver sensitivity (in dbm).

**Power Meter, Fiber Optic**

An instrument that measures optical power emanating from the end of a fiber.

**Receive Cable**

A high quality fiber optic reference jumper cable, attached to a power meter used for loss testing.

**Reference Test Cable**

A short single fiber jumper cable with connectors on both ends used for testing. The fiber and connectors must match the cables to be tested.

**Singlemode Fiber**

A fiber with a small core, only a few times the wavelength of light transmitted, that only allows one mode of light to propagate.

**Splice**

A joint or permanent connection between two fibers. *See Fusion Splice and Mechanical Splice.*

**Step Index Fiber**

A multimode fiber where the core is composed of a material with the same index of refraction.

**Termination**

Preparation of the end of a fiber to allow non-permanent joining to another fiber or an active device, sometimes called *connectorization*.

**Test Source**

A laser diode or LED used to inject an optical signal into fiber for testing loss of the fiber or other components.

**Visual Fiber Tracer**

A device that couples low power visible light from a lamp or LED to allow tracing fibers and testing continuity.

**Visual Fault Locator**

A device that couples high power visible light from a laser into the fiber to allow finding breaks, stress loss, visual tracing and testing continuity.

**Wavelength**

A measure of the color of light, usually expressed in nanometers (nm) or microns ( $\mu\text{m}$ ).

**Wavelength Division Multiplexing (WDM)**

A technique of sending signals of several different wavelengths of light into a fiber simultaneously.

**Working Margin**

The difference (in dB) between the power budget and the loss budget (i.e. The excess power margin).

## **C.3 Acronyms, abbreviations and units of measure**

**AHJ** Authority Having Jurisdiction

**ATR** All Threaded Rod

**the City** City Of San Antonio

**CPR** Coupled Power Ratio

**dB** decibel

**dBm** decibel milliwatt

**EF** Entrance Facility

**EMI** Electro-Magnetic Interference

**EMT** Electrical Metallic Tubing

**ER** Equipment Room

**ft** feet, foot

**HC** Horizontal Cross-connect

**HVAC** Heating, Ventilation, and Air  
Conditioning

**IC** Intermediate Cross-connect

**IDC** Insulation Displacement Contact

**IDF** Intermediate Distribution Facility

**IMC** Intermediate Metal Conduit

**in** inch

**km** kilometer

**kVA** kiloVolt Amp

**LIU** fiber optic interconnect unit

**m** meter

**μm** micron; one millionth of a meter (0.000001 meter); also called *micrometer*

**MC** main cross-connect

**MDF** Main Distribution Facility

**MHz** megahertz

**mm** millimeter

**NEC** National Electrical Code

**NECA** National Electrical Contractors Association

**NESC** National Electrical Safety Code

**NFPA** National Fire Protection Association

**OLTS** Optical Loss Test Set

**OTDR** Optical Time Domain Reflectometer

**RMC** Rigid Metal Conduit

**ScTP** Screened Twisted-Pair

**TBB** Telecommunication Bonding Backbone

**TGB** Telecommunications Grounding Busbar

**TIA** Telecommunications Industry Association

**TMGB** Telecommunications Main Grounding Busbar

**TR** Telecommunications Room

**TSB** Telecommunications Systems Bulletin

**UTP** Unshielded Twisted-Pair

# Appendix D: Bibliography And References

This appendix contains information on the documents that are related to or have been referenced in this document. Many of the documents are in print and are distributed and maintained by national or international standards organizations. These documents can be obtained through contact with the associated standards body or designated representatives. The applicable electrical code in the United States is the NEC.

American National Standards Institute (ANSI)  
25 West 43rd St., 4th Floor  
New York, NY 10036  
USA  
(212) 642-4900  
[www.ansi.org](http://www.ansi.org)

X3.166-1990, *ANSI Standard for Token Ring FDDI Physical Layer Medium Dependent (PMD)*

Z136.2-1997, *American Standard for the Safe Operation of Optical Fiber Communication Systems Utilizing Laser Diode and LED Sources*

American Society for Testing and Materials (ASTM)  
100 Barr Harbor Drive  
West Conshohocken, PA 19428-2959  
USA  
(610) 832-9585  
[www.astm.org](http://www.astm.org)

ASTM B539 2002, *Measuring Contact Resistance of Electrical Connections (Static Contacts)*  
BICSI a Telecommunications Association  
8610 Hidden River Parkway  
Tampa, FL 33637-1000  
USA  
(800) 242-7405  
[www.bicsi.org](http://www.bicsi.org)

*BICSI Telecommunications Distribution Methods Manual*  
*BICSI Information Transport Systems Installation*  
*BICSI Customer-owned Outside Plant Methods Manual*

Telecommunications Industry Association (TIA)  
2500 Wilson Blvd., Suite 300  
Arlington, VA 22201-3836  
USA  
(703) 907-7700  
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Federal Communications Commission (FCC)  
445 12th Street SW  
Washington, DC 20554  
USA  
(888) 225-5322  
[www.fcc.org](http://www.fcc.org)

Federal Communications Commission (FCC) Washington D.C., *"The Code of Federal Regulations, FCC 47 CFR 68"*

Federal and Military Specifications  
National Communications System (NCS)  
Technology and Standards Division  
701 South Court House Road  
Arlington, VA 22204-2198  
USA  
(703) 607-6200  
[www.ncs.gov](http://www.ncs.gov)

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Insulated Cable Engineers Association, Inc. (ICEA)  
PO Box 1568  
Carrollton, GA 30112  
USA  
(770) 830-0369  
[www.icea.net](http://www.icea.net)

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International Electrotechnical Commission (IEC)  
Sales Department  
PO Box 131  
3 rue de Varembe  
1211 Geneva 20  
Switzerland  
+41 22 34 01 50  
[www.iec.ch](http://www.iec.ch)

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The Institute of Electrical and Electronic Engineers, Inc (IEEE)  
IEEE Operations Center  
445 Hoes Ln., PO Box 1331  
Piscataway, NJ 08854-1331  
USA  
(732) 981-0060  
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National Electrical Manufacturers Association (NEMA)  
1300 N. 17th Street, Suite 1847  
Rosslyn, VA 22209  
USA  
(703) 841-3200  
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Batterymarch Park  
Quincy, MA 02269  
USA  
(617) 770-3000  
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Society of Cable Telecommunications Engineers (SCTE)  
140 Philips Rd.  
Exton, PA 19341-1318  
USA  
(800) 542-5040  
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Telcordia (formerly BELLCORE)  
Telcordia Corporate Headquarters  
One Telcordia Drive  
Piscataway, NJ 08854-4157  
USA  
(732) 699-2000

[www.telcordia.com](http://www.telcordia.com)

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Underwriters Laboratories, Inc. (UL)  
333 Pfingsten Road  
Northbrook, IL 60062-2096  
USA  
(847) 272-8800  
[www.ul.com](http://www.ul.com)

UL 444/CSA C22.2 No. 214 02, *Communications Cables*  
*The organizations listed below can be contacted to obtain reference information.*  
Canadian Standards Association (CSA)  
5060 Spectrum Way  
Mississauga, Ontario  
L4W 5N6 Canada  
(800)-463-6727  
[www.csa.ca](http://www.csa.ca)

Electronic Industries Alliance (EIA)  
2500 Wilson Blvd., Suite 400  
Arlington, VA 22201-3836  
USA  
(703) 907-7500  
[www.eia.org](http://www.eia.org)

IPC, Association Connecting Electronics Industries  
3000 Lakeside Dr. 309 S  
Bannockburn, IL 60015  
USA  
(847) 615-7100  
[www.ipc.org](http://www.ipc.org)

International Organization for Standardization (ISO)  
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(301) 657-3110 tel

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www.neca-neis.org

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